MECHANICAL
ENGINEERING
November 1943
A.S.M.E. ANNUAL MEETING
NEW YORK, N. Y. — NOVEMBER 29 — DECEMBER 3, 1943

STEAM FOR INDUSTRY'S WAR JOB

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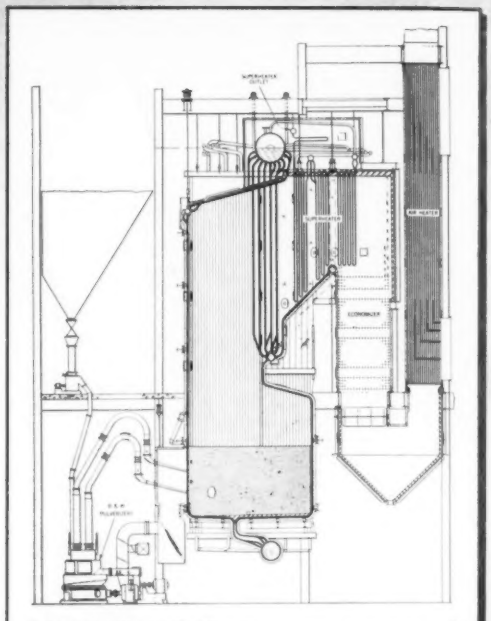

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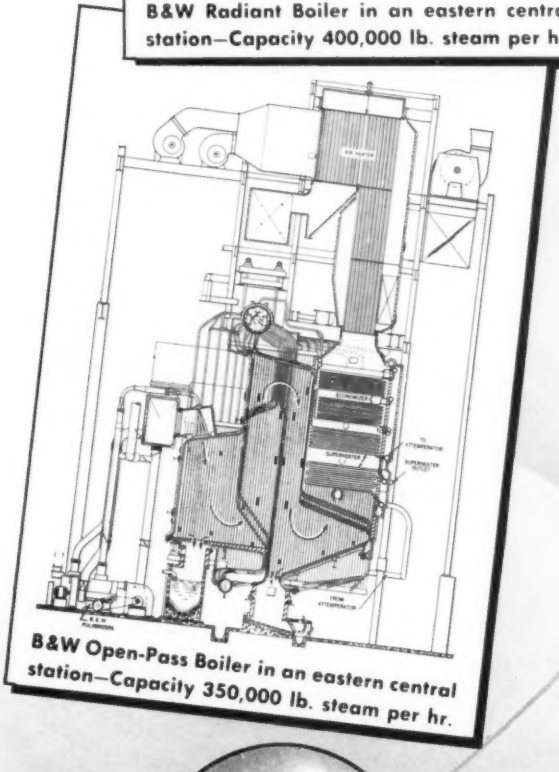

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MECHANICAL ENGINEERING

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VOLUME 65 NUMBER 11

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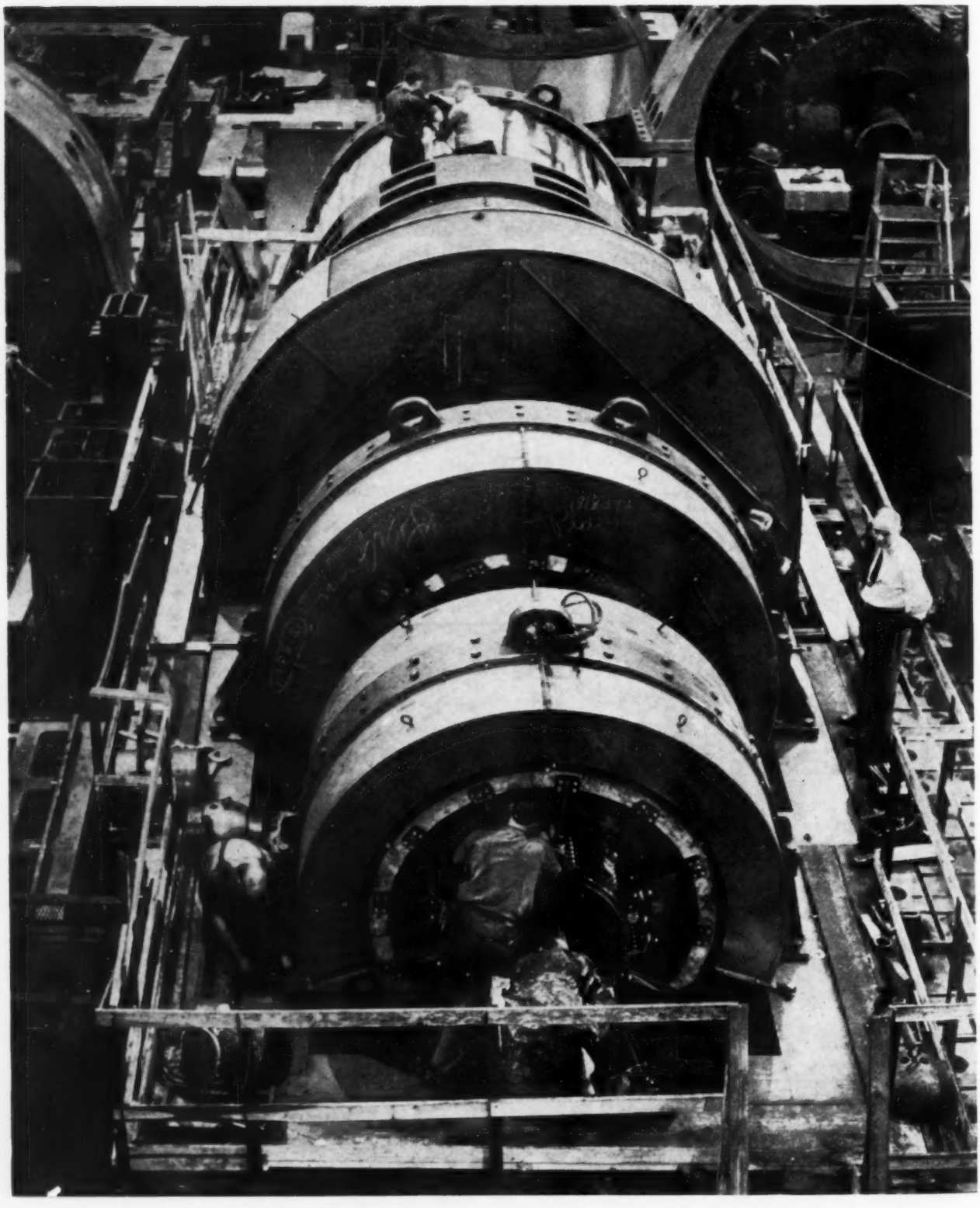

Large M-G Set for West Coast Steel Mill Being Prepared for Shipment at General Electric

VOLUME 65
No. 11

MECHANICAL ENGINEERING

NOVEMBER
1943

GEORGE A. STETSON, *Editor*

The Canadian Meeting

NO evaluation of the technical papers presented at the recent joint meeting of The Engineering Institute of Canada and The American Society of Mechanical Engineers, held at Toronto, Ontario, Sept. 30–Oct. 2, can adequately assess the importance and significance of that occasion. Elsewhere in this issue some of the papers are presented and their excellence can be judged by readers. But only those who were privileged to attend this meeting will have grasped other implications for the future that were uncovered on this occasion.

Of the quality of hospitality enjoyed at Toronto, too much praise cannot be given. Bonds of common interests in a multitude of fields provided means for the instant recognition of personal qualities in the engineers of neighboring and friendly nations. These undoubtedly will grow stronger as time goes on. Members of the councils of the two societies met together and found opportunity to discuss problems to mutual advantage. Thus was laid the basis of co-operation which, important as it is in wartime, should be of even greater value in peacetime when occasions may arise that will require a keen sense of understanding and appreciation of the other fellow's point of view.

1943 A.S.M.E. Annual Meeting

NEVER before has so extensive and varied a program for an A.S.M.E. Annual Meeting been planned as the one which is announced in the *A.S.M.E. News* section of this issue. In new surroundings, the Hotel Pennsylvania, but with the traditional features of more than half a century of such gatherings, the 1943 meeting will probably attract the greatest group of engineers ever assembled by the Society. The variety of subject matter afforded by the program is an indication of Society virility and influence, but it greatly complicates the problem of the individual engineer who will find the fields of his interests discussed in two or more sessions at the same time. Familiar subjects will attract him as in the past, but new ones will also beckon enticingly. He will be hard put to it to arrange his personal program in such a manner that he will enjoy great variety without sacrificing first interests.

A newcomer on the A.S.M.E. Annual Meeting program is the session on Thursday evening, December 2, on Biomechanics which initiates the public appearance of the recently formed committee of the Aviation Division on this subject. Previous mention of this committee and of the subject of biomechanics has been made more than once in these pages. Although the word has an unfamiliar ring to many engineers, biomechanics is a subject that is not new. It relates to that field of interest and design in which the machine and the human body are inseparable parts. For example, motion study and fatigue can be classed as biomechanical subjects on the grounds that the skill and efficiency of the operator and the degree of fatigue he experiences are frequently functions of the machine he operates and may be affected by changes in the design of the machine to bring into consideration the strong and weak points of the human body.

The interest of the Aviation Division in biomechanics, however, is based primarily on the conviction that, by proper co-ordination, airplane design can be made to take advantage of the knowledge which medical men have of the strong and weak points of the human body. If such co-ordination can be properly effected, the lives of many airplane pilots can undoubtedly be saved, the severity of injuries caused by airplane crashes can be materially reduced, and the cause of safety in aviation will be materially advanced. It is hoped that the A.S.M.E. venture into this phase of biomechanics will be accorded the interest it warrants and that its program of usefulness to the nation will be auspiciously initiated.

Let the People Know

IN THE discussion and the working out of plans for a postwar world toward which we look with such keen interest and concern, attention should be focussed on adequate publicity of scientific and engineering thinking and accomplishment. It will be important to "let the people know," as otherwise a great opportunity will be lost to make fully effective the benefits that should be derived from both of these great sectors of future advancement.

Life after the war will be inextricably bound up in science and engineering. There is no sector of it from the home to the halls of government and the market place where technology will not be of prime importance. The complexities that it introduces into the problems of government and human relations require the greatest degree of intelligence on the part of those in positions of responsibility and of confidence on the part of those whose lives and fortunes are involved. Only by widespread knowledge can successful operation of society be assured.

Fortunately, the stage is set for the spreading of knowledge and understanding that should train competence on one side and generate confidence on the other. Thousands of men will be released from the armed forces equipped with partial skills and knowledge on which to build for the future. Correspondingly, thousands of men and women will have had more than the customary contact with some phases of a world dependent on science and large-scale production. That the number of young people presenting themselves for education and vocational training after the war will be greater than ever before can not be doubted. It is known that the govern-

ment itself will make opportunities more numerous and more accessible than they were before the war. These factors are on the credit side.

On the otherside of the ledger, however, are the factors of ignorance, suspicion, social unrest, desire for security, and false optimism of what science and engineering can do without thoughtful, purposeful, and determined guidance. These are real hazards. It is not enough, therefore, to develop in the isolated and professional atmosphere which surrounds universities, research laboratories, and learned societies the knowledge by which civilization may advance if given the opportunity. Truth and knowledge must be shared with laymen and the people; otherwise one group gets ahead of its following, and ignorance, false hopes, and misunderstanding flourish.

It should be a major portion of the programs of engineering societies, to mention but a single group, to develop the knowledge and understanding of the people in areas where engineers have competence and can undertake instruction. The war has generated interest and a certain amount of respect and confidence. To maintain interest, respect, and confidence requires purposeful action. To succeed in our own endeavors and to advance the public well-being it will be necessary to let the people know.

What About Metals?

SEVERAL months ago the Metals Engineering Division of The American Society of Mechanical Engineers circulated a questionnaire among its members to find out what subjects were of greatest interest and importance to them. The results of the questionnaire were illuminating and extremely helpful. They uncovered the fact that there exists among mechanical engineers a widespread and deeply rooted interest in metals and in knowledge of their use in design, their properties and applications, and the manner of working them.

So far so good. The question remained, however, as to how best to meet the uncovered needs. There was, of course, the medium of technical meetings and papers built into carefully prepared programs that would uncover and place on record the desired information. A little reflection, however, soon uncovered the fact that if reliance were placed solely upon this means, the surface only would be scratched and the fundamental need would still be unmet; for it is evident that the subject is an extensive one and new techniques and information are developing at a rapid rate. Even a casual survey showed that the material on which members requested information was so great and varied that the entire meeting and publication facilities of the Society could be devoted to it for a couple of years without exhausting the possibilities. Obviously, either it would be necessary to concentrate on this one subject alone to the exclusion of all others or some other method would have to be devised to supplement the meetings procedure.

An obvious device which occurred to the Metals Engineering Division and to the Committee on Professional Divisions, which immediately recognized the existence of an opportunity for service that constituted a major challenge to Society leadership, was the preparation of a handbook which would cover much more quickly than it would be possible to do with the usual series of meetings and technical papers the subject matter members seemed to be so universally lacking. Hence, an investigation was immediately started on the possibilities of providing such a handbook.

The problem has major dimensions. There must first be determined the scope and content of such a handbook. Next, sources of material must be discovered and competent authors and editors secured to carry on the tremendous work involved. Last, but by no means least, some practical means must be found for the financing of such a project.

It is not possible to announce at this early date that the project is organized and in operation. However, at the suggestion and with the recommendation of the Committee on Professional Divisions, the Executive Committee of the Council of The American Society of Mechanical Engineers, at its meeting in Toronto, as noted in the *A.S.M.E. News Section* of this issue, voted to undertake the project.

While the Committee on Professional Divisions was making its preliminary studies relating to the handbook project, several other books and projects of a related nature were found. One of these was the forthcoming book, by J. F. Young of the General Electric Company, "Materials and Processes Used in Electrical Manufacturing," prepared with the assistance of the Schenectady Works Laboratory and the Research Laboratory of the General Electric Company, to be published by John Wiley and Sons, Inc. It is a tribute to the cordial relations that exist between these two companies and The American Society of Mechanical Engineers that permission was obtained to publish the initial chapter, "The Nature of Pure Metals," in this issue of MECHANICAL ENGINEERING.

One of the problems involved in the proposed handbook is that of co-ordinating existing information in a form readily usable to mechanical engineers. An extraordinary amount of information is available, and much of it is in handbook form. In most cases, however, this material is prepared by and for metallurgists. It would be splendid if all mechanical engineers, designers, and production engineers were such thorough metallurgists that the rich literature in the field of metals would be usable by them. Such, however, is not the case. What the mechanical engineer wants to know must be gleaned from existing knowledge by someone competent to evaluate and interpret it and reassembled it in a form that meets the needs of the designer and manufacturer. This requires some means of presenting basic information in readily comprehendable form so that the engineer can start with a review of fundamental principles organized with his needs particularly in mind. Mr. Young's article is of this nature and was selected for publication for this reason. Secondarily, publication of "The Nature of Pure Metals" is an indication to members of The American Society of Mechanical Engineers that action is being taken to fill a need which they themselves have expressed. In the months that must elapse before the handbook can be made available, such articles as Mr. Young's will help to fill the gap. It is an encouraging circumstance that Mr. Young has consented to serve actively on the committee whose responsibility it will be to outline and prepare the handbook.

AN AUTOBIOGRAPHY

Harry R. Ricardo, Honorary Member, A.S.M.E.

I WAS born in London January 26, 1885.

My father, Halsey Ricardo, was an architect by profession and an artist by instinct and inclination. My mother, nee Rendel, came of an engineering family—daughter of Sir Alexander Rendel and niece of Lord Rendel, George, and Hamilton, Rendel. Sir Alexander was senior partner in the firm of Rendel & Robertson (later, Rendel, Palmer & Tritton), Consulting Engineers, while his three brothers were all active members of the firm of Armstrong's.

As a child, I spent the winters in London, and saw a good deal of my father's artist friends, such as Burne-Jones, Walter Crane, William De Morgan, and the summers at my grandfather's country estate, where I met mostly engineers such as my three Rendel great uncles, Sir Andrew Noble, Sir Percy Girouard, Sir Ralph Wedgwood, Campbell Swinton, and many others.

HARRY R. RICARDO

After a preparatory school at Rottingdean, I went to Rugby in 1898, where I had a quite undistinguished but very happy time. I did, I am afraid, the very minimum of work but was a fairly good athlete and spent nearly all my spare time in the well-equipped school workshops where I made, among other things, a coal-fired steam-motor-bicycle—a crude, dangerous, but most exciting machine. At this period and, in fact, as far back as I can remember, I was intensely keen on all forms of mechanical engineering and more especially on methods of manufacture. From the age of 10 I had owned and used a screw-cutting lathe and by the time I went to Rugby, I had become quite a skilled mechanic. While at Rugby School, I spent a good deal of my spare time at the engine works of Messrs. Willans & Robinson (now the English Electric Company). At that time they were building their famous high-speed central-valve steam engine and were introducing new and up-to-date methods of manufacture, such as grinding, broaching, etc., which fascinated me intensely.

I left Rugby early in 1903, spent a few months in Messrs. Willans test shop, where I learnt a good deal about the erection and testing of steam engines, and then went up to Cambridge (Trinity College) in the autumn of that year.

At Cambridge, I read for the mechanical sciences Tripos, but after about 18 months, Prof. Bertram Hopkinson invited me to assist him in a series of researches he was then about to start on the internal-combustion engine. I accepted the offer with alacrity and abandoned the Tripos in favor of an ordinary degree. Until this time my interests had lain in the direction of mechanical engineering generally and manufacturing processes in particular, but I had taken no particular interest in internal-combustion engines as such. Under Hopkinson's inspiring tutelage, I soon became thrilled with the scope and possibilities of the internal-combustion engine which, at this time, was coming into wide use with the advent of

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[Harry R. Ricardo was made an honorary member of The American Society of Mechanical Engineers in 1942. Because of the war he could not come to this country to receive the certificate at the 1942 Annual Meeting and hence members of the Society were denied the pleasure and privilege of meeting him, a delightful experience as those who have met him can attest. But next to that experience the reading of the story of his life will serve to make him better known to engineers in the United States.

Mr. Ricardo did not write this biographical sketch for publication. When he was nominated for honorary membership, one of his friends in this country wrote to H. L. Guy, secretary of the Institution of Mechanical Engineers in London, for accurate biographical data. Without telling why the data were wanted, Mr. Guy asked Mr. Ricardo to prepare a biographical note. The material here published was the result. Forwarded to the United States by Mr. Guy, it came into the hands of the Editor who immediately asked Mr. Ricardo's permission to publish it as a means of making him better known to his fellow A.S.M.E. members.

Permission was granted with reluctance. Wrote Mr. Ricardo:

"When Guy asked me to prepare it, he told me, at the same time, to cast all modesty aside, and assured me it was not for publication but only for record. I never for one moment thought of it as appearing to my contemporaries, and I rather shudder at the idea of it now.

"If you do think fit to publish it, could you not tone it down a little, and anyway, omit or condense the list of awards, etc., which looks particularly blatant. You say that the publication of such a biographical note is a source of encouragement to young men, but I am a little doubtful whether this applies in my case for I started almost at birth with every advantage that circumstances or money could provide, and with a more than usual share of good luck into the bargain, so that I really never have had any struggle at any stage in my career. The best reply I can make is that I leave it in your hands as to publication, but shall hope that you will draw the kindly veil of modesty over parts of it, at least to the extent that I may still have the courage to meet once again my friends in your country."

This note of explanation is therefore offered out of respect for Mr. Ricardo's feelings.—Editor.]

the motor car. Hopkinson's researches covered a wide field; the principal items on which I was engaged included:

1 The design and development of a high-speed optical indicator.
2 A detailed analysis of the performance of a modern (1904) petrol engine.
3 A comparative analysis of that of a contemporary gas-engine.
4 Comparative studies (with the help of Hopkinson's indicator) of the combustion of gaseous mixtures in closed vessels and of the same mixtures in the cylinder of a working engine.
5 An investigation into the phenomenon of preignition in the engine cylinder.

Looking back, I think that Bertram Hopkinson was the most brilliant and inspiring experimentalist I have ever met. He took nothing for granted, had no preconceived ideas or prejudices, and was always ready to scrap any theory, however cherished, if the evidence warranted. He had also the most acute perception, coupled with sound and balanced judgment. He was, too, essentially practical.

While at Cambridge, I spent also a great deal of my time in the engineering workshops, where I designed and built a 15-hp racing motor bicycle, a large and heavy machine of the conventional four-stroke type, and later a two-cycle engine in which, as a result of my work with Hopkinson, I sought to operate with a stratified charge in combination with a high degree of turbulence. This rather ambitious attempt proved a partial success. At Hopkinson's invitation, I stayed on at Cambridge after taking my degree, in order to complete some researches on which he was then engaged.

After leaving Cambridge in 1907, I joined my grandfather's firm, Rendel & Robertson, consulting civil engineers to the Indian State and other railways and to many other undertakings, such as docks, bridges, etc., in all parts of the world. For the first three years with this firm, I served as an inspector of machinery and equipment required by the firm. This proved intensely interesting and instructive, the more so since the type of machinery involved ranged through every phase of mechanical engineering, while my work as inspector brought me into contact with a great many firms. It involved also a good deal of traveling on the Continent, for much of the special equipment required for bridge building, harbor works, etc., was produced in France, Belgium, and Germany, and I had opportunities for seeing and comparing the widely different manufacturing methods employed in different countries.

In 1910 I persuaded my grandfather to let me start a designing department to deal with the often highly specialized mechanical equipment required for bridge building and such like undertakings. This proved absorbingly interesting to me for our designs ranged over a wide field, though mainly concerned with hydraulic and pneumatic equipment. It had been arranged that I should become a partner in the firm on my grandfather's death or retirement. He intended to retire in 1914, and early in that year, in order to broaden my experience and bring me up to date, I was sent to America for four months to visit engineering establishments there, followed by a similar tour of European firms in Germany, Italy, Holland, and Sweden.

During these years 1907–1914, I continued, in my spare time, to carry on with the research work which I had started at Cambridge under Hopkinson's guidance and to develop the two-cycle engine I had built there and of which I constructed several new versions in my own small workshop. In particular I had been impressed, while at Cambridge, with the effect of turbulence on speeding up the whole process of combustion and by the experiments Hopkinson had carried out on preignition. During the latter experiments, 1905–1907, we had observed that the "knock" so prevalent in petrol engines was not necessarily associated with preignition, and Hopkinson had expressed to me the opinion that it might be due to the setting up of an explosion wave in the burning gases. This suggestion impressed me deeply, all the more so since my cherished two-cycle engine suffered acutely from "knocking," which set an early limit to the power it could develop. I determined, therefore, to investigate this question. I soon satisfied myself that the "knocking" had nothing to do with preignition, though preignition might develop as the result of persistent knocking.

About 1910, I carried out a number of experiments with a number of diaphragms fitted in various positions in the wall of the combustion chamber of my engine, to each of which mirrors were attached, so that I could detect, optically, their deflection during combustion. These experiments showed that under knocking conditions one of the diaphragms would deflect far more than the others, and that, always the diaphragm most remote from the sparking plug. By changing the position of the sparking plug I could transfer the deflection to another diaphragm, and so on. These and other experiments satisfied me that the phenomenon of knocking was the setting up of an explosion wave due to the self-ignition of a small part of the working fluid after compression by the oncoming flame front, and I was satisfied, too, that very heavy knocking could be caused by the self-ignition of only a very small fraction of the total combustible charge. During the course of these experiments (1910–1912) I found that the tendency to knock depended largely upon the ource of the petrol and that it could be eliminated completely by the use of benzole. At the time, I did not publish any of these observations but I reported them to Hopkinson who was very interested and helped with many useful suggestions, and to many engineers of my acquaintance, but none of the latter could I convince. I was assured that, in spite of my observations, knocking was none other than premature ignition of the whole combustible charge.

About 1911 I became very interested in aviation, which was then in its infancy; in 1912–1913, I designed and built an experimental four-cycle engine with a variable supercharge, with the object of maintaining ground-level density up to high altitudes. This engine ran very well, but though I demonstrated it to a good many engine builders, I could not, at that time, find any to take an interest, their attitude then being that aircraft would never fly high enough to require supercharging. By this time I had become quite convinced that the knocking, or "detonation" as I preferred to call it, was a very serious matter, that it was setting an early limit to the power obtainable from a petrol engine, and that its incidence was a function, or very largely a function, of the chemical constitution of the fuel. I found, too, that my experimental supercharging engine provided an ideal fuel-testing unit, in that, by increasing the supercharge, I could induce detonation at will with almost any fuel.

At the end of 1913, I went to America and was abroad for about six months, returning just before the outbreak of war in 1914.

In view of the war, my grandfather felt that he would not be justified in retiring as he had intended, and I returned to the charge of my small designing department, which was kept very busy with a multitude of military problems, and I had, therefore, little leisure to continue with my private research.

In 1915 my firm were consulted on various problems relating to tanks, which were then being developed in great secrecy. Since these were, for the most part, mechanical problems, they became my chief concern. In October, 1916, I was asked if I would be prepared to design and, with the help of my firm, to organise the production of engines for tanks, since the existing engines had not sufficient power and were unsuitable in other respects. This I undertook, little knowing the magnitude of the task I was embarking upon. Thanks to the experience and splendid organisation of the firm, a group of engine manufacturers was at once got together; one of them was appointed as the parent, and a magnificent spirit of co-operation was aroused.

It was agreed that I should prepare the designs and that the detailed working drawings should be prepared by the parent

firm, Messrs. Mirrlees Bickerton & Day, in co-operation with the other firms. Mr. Windeler, chief engineer of Mirrlees, undertook to supervise the working drawings and ensure that they accorded with the machining facilities of the group. With the help of two young draughtsmen from the parent firm I prepared designs for an engine of 150 hp of a decidedly unorthodox type, in which I employed a crosshead piston and a number of other novel features, believing that I would have time and opportunity to fall back on a more orthodox design if things went wrong, for at that time the immediate construction of only 12 experimental engines was contemplated.

The drawings were completed and the construction of the experimental engines well under way by January, 1917, when, to my horror, the order was increased suddenly from 12 to 1400 engines; at the same time, I was informed that the entire production of tanks was to be equipped with these engines and that no second string was available or in contemplation. It was too late now to repent of my unorthodoxy, and I could only pray that Providence would intervene on my behalf. I received all possible help and encouragement from all the firms engaged on the construction of these engines, in particular from Mr. Windeler of Messrs. Mirrlees Bickerton & Day, the parent firm, and Commander Bryant of Messrs. Peter Brotherhood, both of whom realised to the full my anxiety and did everything they could to make a success of the enterprise.

The first prototype was completed by Brotherhoods in March, 1917, and, to my unbounded relief, passed all its preliminary tests without any serious troubles. The second was completed in April by Mirrlees, and others followed in quick succession. In the event, thanks largely to good luck and still more to the combination of kindly help and great experience freely given by all the makers, the engines proved quite satisfactory; a few teething troubles were encountered, but these proved to be only very minor and were quickly and easily overcome, so much so that by the end of 1917 the output of engines had reached nearly 100 per week, many hundreds were already in operational service, and the number ordered had been increased to 6000.

About the middle of 1917 I was asked to design two larger versions, one 225 hp and another of 300 hp, for the next series of tanks. Thanks to the experience gained with the 150 hp, these latter went through quite easily, with practically no teething troubles; some 900 of the 225-hp engines were completed and a few hundred of the 300-hp type.

In 1916 my grandfather died and the partnership was open to me. I had, however, become so steeped in internal-combustion engines that I preferred to concentrate on that subject alone, which formed no part of my firm's normal business. I decided, therefore, to set up as an independent consultant, and a small private company was formed under the chairmanship of the late Campbell Swinton, F.R.S., who had taken a friendly interest in my career ever since my childhood days. One of my Cambridge colleagues, Mr. H. A. Hetherinton, joined me in this venture and virtually took over the tank-engine development after 1918. My late firm most generously offered to keep the partnership open for as long as I liked, in case the new venture should fail, and they further helped me greatly in the early days by handing over to me any of their client's problems relating to internal-combustion engines.

During 1915–1916, I carried on, to some extent, with my private research work which had developed largely into the testing of different fuels in their relation to detonation, and into the testing of different forms of combustion chamber, with the object of reducing detonation on any given fuel by:

1 Reducing as far as possible the length of flame travel.

2 Providing ample cooling for the unburnt gas remote from the sparking plug, i.e., in the zone from which detonation might be expected to start.

3 Increasing turbulence in order both to speed up the combustion process and prevent the isolation and subsequent detonation of any pocket of unburnt gas.

As a result of these researches, I was able to provide, in the second series of tank engines, a vastly improved form of combustion chamber and so improve greatly the performance of these later engines.

Shortly after the outbreak of war in 1914, Hopkinson asked me to prepare a thesis on the design of engines of high power output, to be circulated to all those engaged upon the design of aero-engines and to the various technical departments of the Government.

This thesis, "Engines of High Output," was subsequently released for publication, as a series of articles in *The Automobile Engineer* (published 1916–1917). As a result of it, I was invited to act as consulting engineer to several of the firms then engaged on the development of aero-engines, e.g., Rolls Royce, Bristol, Napier, Armstrong Siddeley, and in January, 1918, was appointed consulting engineer to the Air Ministry, all of which appointments I still hold.

Campbell Swinton was delighted with the progress of events and readily agreed to the building, by our small company, of a comparatively large experimental laboratory at Shoreham-by-Sea, Sussex; this was started during 1918 and completed early in 1919.

During the war 1914–1918, I served on a number of committees, including one dealing with fuel-supply problems, under the chairmanship of Sir Robert Waley-Cohen. To him I told of my theories on the subject of detonation and its relation to the fuel. I explained to him that, though I had had difficulty in knowing exactly of what my samples consisted, I had been able to show that petrols with a paraffin base (low specific gravity) were the worst offenders as regards detonation, while those with an aromatic base (high specific gravity) were the best, while pure aromatics, such as benzene, toluene, and xylene, appeared to be immune from detonation. In this he was intensely interested. He then told me that in Borneo thousands of tons of petrol of high aromatic content were being burnt to waste, merely because they did not comply with the existing specifications based on specific gravity. He at once arranged for samples of this fuel to be sent to me from Borneo and, as expected, I found that it was greatly superior to any petrol then in use in this country, and I asked to be allowed to use it for tanks. To this the Military would not agree, but at least the large-scale waste of the very best petrol was stopped.

In view of this observation, Sir Robert then asked me to undertake, as soon as the War was over, a really comprehensive research into the behavior of various fuels on behalf of his company (The Asiatic Petroleum Company). This, then, formed the first piece of large-scale research undertaken at our new laboratory at Shoreham, and it occupied three years. For this work I was fortunate in being able to enlist the help of Sir Henry Tizard, Dr. Pye, Oliver Thornycroft, and the cooperation of the Shell Company's chemists and technical staff.

For this research we designed and built a considerable amount of special apparatus, including a very high-efficiency engine in which the ratio of compression could be varied over a wide range while running at full power; another variable-compression engine with a toggle motion in place of the ordinary crank mechanism, whereby a single compression stroke could be made, and the piston locked at top dead center, and a slightly revised version of my original supercharging engine, in which the compression ratio was constant and the supercharge variable.

With all this equipment and technical assistance we were able to carry out a very complete investigation; this confirmed generally my earlier findings as to the importance, nature, and mechanism of detonation and as to the influence on detonation of the chemical composition of the fuel. Full reports of these researches were published in the *Automobile Engineer*, under the

titles "The Character of Various Fuels for Internal Combustion Engines," by Tizard and Pye; "Influence of Various Fuels on the Performance of Internal Combustion Engines" by Ricardo and Thornycroft, and (more especially in relation to alcohol fuels) in the Empire Motor Fuels Report.

Our researches revealed that the tendency to detonate was by far the most important criterion by which to judge a fuel for spark-ignition engines. We expressed this tendency in terms both of the highest useful compression ratio (H.U.C.R.) at which a fuel could be used in our variable-compression engine, and of the equivalent proportion of toluene in heptane to match such a fuel (toluene number). Later iso-octane took the place of toluene as a standard, and the toluene number was, therefore, exchanged for the octane.

This research, financed and assisted by the Shell Company, helped greatly to carry us through the first difficult years following the Armistice. Its immediate practical result was a rapid improvement in the standard and uniformity of fuels on the market.

During the War I had, in my own workshop, been carrying out experiments on different forms of combustion chamber with a view both to reducing detonation by mechanical design and to improving efficiency generally. At that time the side-by-side valve engine was in general use. It was notoriously inefficient and very prone to detonate but had many important advantages from a mechanical and manufacturing point of view. The general view appeared to be that the side-valve engine was silent, cheap, and reliable, but that, if an efficient engine was required, it was necessary to employ overhead valves. I was not prepared to accept this; after comparing the two, I was convinced that the higher efficiency of the overhead-valve engine was to be accounted for by:

1 Much greater turbulence.
2 A shorter flame travel and hence less prone to detonate.

During 1917, I set out to try to produce, in the side-valve engine, the same combustion conditions as obtained in the overhead valve. This I sought to do by:

1 Concentrating the main volume of the combustion chamber over the valves, leaving only the bare minimum of mechanical clearance between the piston and cylinder head.
2 So chilling the portion of the charge trapped in the shallow laminum between piston and cylinder head that it could not detonate.
3 Shortening the flame travel by placing the sparking plug approximately in the center of the main combustion space.

This, after a good deal of experimentation, proved entirely successful, and I was able to obtain, from a side-valve engine, the same power output and efficiency as from an overhead valve of the same dimensions. Immediately after the War, I obtained a patent for this form of combustion chamber—a patent which led to a rather important patent test case, which we won, in 1932. It took several years to convince the trade and the public that, at no extra cost, a side-valve engine could be made quite as efficient as an overhead, but eventually this was accepted, and for the last ten years, at least, all side-valve engines in all parts of the world employ this form of combustion chamber. In America, where the overhead-valve engine had held sway, it was adopted, first by the Chrysler and Waukesha Companies, and soon after became general practice, with a consequent swing back to the use of side-valve engines.

While the fuel and other researches were being carried out at Shoreham, our design staff were kept fairly busy on the design of new engine models for a variety of purposes. We were fortunate in having established, during the War, a good connection with a number of leading engine-building firms, who employed us as consultants, or came to us for designs of new models, or both.

After completing our fuel research in 1921, I started next as a main line a research into the possibilities of the sleeve-valve engine, more especially with a view to its use in high-powered aircraft. In this we were able to obtain the support of the Air Ministry, who financed the work. After analysing the various forms of sleeve valve which were in use, or had been proposed, I soon became convinced that the type of single sleeve patented by Burt and McCullum held out by far the greatest promise. Its career up to that date had not been happy, but it seemed that it had been dogged by ill luck and commercial mismanagement, rather than by any inherent technical faults. I was attracted to the sleeve valve for the attainment of very high outputs, for three main reasons:

1 The head, being valveless, left complete freedom of maneuver in the design of the combustion chamber.
2 The absence of a hot exhaust valve would reduce greatly the tendency to detonate.
3 The absence of valve springs removed one very definite limitation on the speed of operation.

We completed our first experimental sleeve-valve engine in 1922, a large single-cylinder unit, and at once found that the absence of an exhaust valve and central ignition enabled us to raise the compression by one whole ratio before detonation intervened. We encountered, of course, a large number of mechanical difficulties, but none of them proved very formidable.

By 1923, we had completed, successfully, a 50-hour Air Ministry test at an output and efficiency far in advance of anything that had been achieved at that date, and I had hoped that the Air Ministry would at once get one of the engine builders to put in hand a prototype aero-engine, but this was not to be.

In 1924 we built, at our own expense, a smaller but much higher speed unit, which developed no less than 100 hp per l of cylinder capacity at a speed of 6000 rpm, or nearly double that obtained previously, but still the Air Ministry, though willing to finance research, were not prepared to advocate development.

Several years later I succeeded in persuading Sir Roy Fedden, of the Bristol Aeroplane Company, to build a complete aero-engine. This, with much misgiving, he did, but it was not completed until about 1934. Known as the "Perseus," it was a nine-cylinder radial engine, with cylinders $5^3/_4$ in. $\times$ $6^1/_2$ in. After a few initial troubles it proved a great success and was adopted as standard for the Empire flying boats. Later, he developed a 14-cylinder version, now well known as the "Hercules." On the outbreak of the present War the entire capacity of the great Bristol aero-engine factory was turned over to the manufacture of sleeve-valve aero-engines. That so many years should have elapsed between the completion of the research and its practical development was bitterly disappointing to me; all the more so, since the advantages of the sleeve-valve aero-engine were most apparent in the days when we were using relatively low-octane fuels.

After completing our research on the sleeve-valve engine, I chose, as our next main line of research, the light high-speed Diesel engine. Here again the Air Ministry at first supported and financed this line of development. As in the case of the side-valve petrol engine, I had never been satisfied that there was any fundamental reason why the Diesel engine should not be operated at high speed and at high power outputs. The argument that the process of combustion in a Diesel engine was so complex that it could not be hurried left me quite unconvinced, for my experience with spark-ignition engines had satisfied me that no such limit existed, given sufficiently rapid movement of the participants of combustion.

As in the case of the sleeve-valve engine, we first investigated and analysed such work as had been done in this direction and, at the same time, carried out a number of preliminary experiments on the combustion of fuel sprayed into air. As I had fully expected, the speed of combustion was found to be simply a direct function of the relative speed of the fuel droplets and

the air. Since there was an obvious and fairly early limit to the speed which could be imparted to the liquid fuel, it seemed logical to me that the line of attack lay rather in speeding up the movement of the air in the combustion chamber.

Our first experiments were carried out on a sleeve-valve engine in which, by suitable shaping of the port entry, we could obtain any desired degree either of general turbulence or of orderly flow. At that date (1925) no suitable injection pump had been developed, and we spent some time on the design and development of a high-pressure pump to give accurate metering and timing. This done, we at once obtained promising results and found no difficulty whatever in operating an engine on the Diesel cycle at a speed of well over 2000 rpm and that at an efficiency comparable with that of large slow-speed Diesel engines. We found, however, that the high and long sustained pressures necessitated a considerable increase both in the stiffness of the engine structure and in the bearing surfaces required, as compared with a petrol engine of similar dimensions. In view of this I had to report to the Air Ministry that, while there appeared to be no fundamental obstacle to the development of high speed and high output, such an engine would, in the four-cycle form at any rate, always be somewhat heavier than a petrol engine of similar power, and that, though this would form a very serious handicap from the point of view of aircraft, it would probably matter little in the case of other commercial uses. This view was accepted by the Air Ministry who very generously agreed to our making use of the results of our research in other directions.

About this time (1926–1927), the Shell Company, with whom we had always kept in close touch, was anxious to extend the market for Diesel fuel, of which there was at that time a large surplus. They therefore agreed to carry on with the financing of our research on four-cycle Diesel engines for commercial purposes generally, while the Air Ministry supported a further research into the possibilities of an ultra light version operating on the two-stroke cycle. As in the case of our earlier fuel research, the Shell Company gave us every possible assistance and encouragement.

By 1927, we felt that our researches had developed far enough to permit us to design a marketable engine. Our first design was for a relatively large sleeve-valve engine of 300 hp for stationary use, to run at a normal speed of 900 rpm. This design was adopted by Messrs. Peter Brotherhood who, during the years 1923–1938, built and sold a large number of these engines for electric power plants, pumping stations, and auxiliary engines in the British Navy and Mercantile Marine. The Shell Company's main goal was, however, the use of Diesel engines for heavy road vehicles, but it was painfully evident that in this field the prejudice against the use of sleeve valves was impenetrable. We therefore set to work to try and reproduce, in a poppet-valve engine, the conditions and results obtaining in the sleeve valve. This proved more difficult but, by 1929, we had succeeded in obtaining a satisfactory performance, in that we could obtain, within a fraction, the same power and run at the same maximum speed as a contemporary petrol engine of equal dimensions.

During this year, and in co-operation with the A.E.C. (Associated Equipment Company), we designed and developed a light 6-cylinder Diesel engine of 130 hp at 2200 rpm, weighing 1400 lb. After preliminary trials on a prototype engine in our laboratory at Shoreham, the A.E.C. put into service, as a large-scale experiment, 100 vehicles equipped with such engines. A large proportion of these were put into buses operating in London, a few into long-distance high-speed coaches (Green Line), and the rest into heavy lorries operating on very heavy duty. Their success was immediate and to me rather unexpected, for they proved equally reliable under a wide variety of arduous service. In the London service, in heavy traffic, their fuel consumption was just half that of the similar petrol-engined buses.

After the success of this large-scale experiment, the A.E.C. decided to concentrate the whole of their large production on the manufacture of Diesel-engined vehicles, a lead which was followed very shortly by most of the other builders of heavy commercial vehicles in this country.

From 1932 on, until the outbreak of the present War, almost our entire designing facilities were concentrated on the design of light high-speed Diesel engines for some forty-odd different firms in this country and on the Continent, the latter including Berliet and Citroen (France), M.A.N. (Germany), Fiat and Breda (Italy), John Cockerill, Carels Freres, and Brossell (Belgium), Werkspoor, Stork, and Thomassen (Holland), C.K.D. (Czecho Slovakia), while our research facilities were largely occupied in exploring the many mechanical and combustion problems connected with their further development, though at the same time, we were still carrying out a large amount of research both for the Air Ministry and for Messrs. Rolls Royce, in connection with aero-engine development generally.

The foregoing covers, broadly, the main lines of research to which I have been devoted but, in parallel with these, we carried out a large number of other researches into the various mechanical problems connected with internal-combustion engines, e.g., lubrication, cylinder wear, bearing materials, etc. Of more recent work, I can say very little, for it has all been devoted to wartime problems and naval, military, and air-force equipment.

Cushing, N. Y.

TWILIGHT ON THE NEW YORK WATERFRONT

(For story of 1943 A.S.M.E. Annual Meeting, Nov. 29–Dec. 3, see pages 841–850.)

Steam Generation for MARINE *and* STATIONARY SERVICE *in the* UNITED STATES, 1933-1943

By E. G. BAILEY

BABCOCK & WILCOX COMPANY, NEW YORK, N. Y. MEMBER A.S.M.E.

STEAM-generating plants, on both land and sea, are furnishing power satisfactorily for the production of munitions, equipment, and supplies as well as for their transportation—and also for the movement of fighting ships themselves—without the need for any new special designs or major changes in existing types of boiler units. This does not mean that we are using old out-of-date equipment; new and advanced designs of all types of boilers now being used have been largely developed since the early thirties. Fortunately, they were developed far enough in advance of the present emergency to have been thoroughly tested and proved.

The shortage of steel and other critical material has greatly restricted the extension of many electric-utility systems and many industrial plants have been forced to continue with what they had or bring back into use many boilers built fifteen to thirty years ago. This has required that practically all steam-generating units be operated at higher loads and use factors than ever before.

This high-duty service is furnishing an opportunity to determine any shortcomings or limitations that might exist as well as the features of reliability, all of which are valuable guides in evaluating the best designs for the future, when new plants will be built after the war.

Some points of prewar development that have proved to be of important significance, and which apply to both stationary and marine use, are summarized as follows:

Welded Drums. As far back as 1930 the United States Navy approved the use of fusion-welded boiler drums. The A.S.M.E. Code approved fusion-welded drums for stationary boilers in 1931. This technique has been developed and proved to be satisfactory. The use of welded boiler drums has been a very important factor in connection with higher steam pressures and in the saving of steel.

Steam Separation. Wet steam has always been a problem in boiler design and operation. When superheaters were first put into general use, they usually evaporated the moisture which came over from the boiler, with the result that dry dust from the solids in the moisture, which we now speak of as "carry-over," were left in the steam. These solids or carry-over remain in the superheated steam in some form and in some cases cause deposits on turbine blading. Great improvements in the methods of separation of water from steam are now widely used in stationary and marine boilers with good results which are little short of absolute perfection.

Waterwalls for Furnaces. While many types of boilers such as the Scotch marine, the locomotive, and even many of the early water-tube boilers had water-cooled furnaces, there was a period during which the furnaces were largely of refractory-wall construction. For better combustion, furnaces were enlarged until refractory trouble brought about a change toward water-cooled furnaces. During the past twenty years, there has been a steady and permanent increase in the amount and suitability of water-cooling construction for furnaces burning all kinds of fuel. Waterwalls are extensively and satisfactorily used in stationary and marine service; in this latter, they have resulted in marked savings in weight and space for a given steam output.

Feedwater Treatment. Continued high rating has been made possible by many factors, among which is the important problem of keeping boilers free, or more nearly free, from scale and dirt through chemical treatment of feedwater. Better condensers and deaeration of feedwater should also be mentioned.

Chemical Cleaning. In both stationary and marine plants, many boilers, economizers, and waterwalls are now cleaned entirely or in part by acid. An inhibitor, which does not reduce the effectiveness of the acid in removing scale and sludge, is used to prevent action on the metal.

Fuel Burning. Important progress has been made in equipment and methods for burning oil in stationary and marine boiler furnaces, with special emphasis placed on the leadership of the United States Navy.

Coal burning made great strides in the decade preceding the war, especially in pulverized fuel in the larger industrial and central-station units. The spreader type of stoker has won a position of importance in smaller land boilers and also in coal burning marine boilers.

Meters and Automatic Combustion Control. Boilers are being operated at higher rates and with better efficiency than they could possibly have been without the almost universal use of meters and automatic control of feedwater and combustion conditions. Superheat control might also be included here. Boiler and furnace designs have been developed to bring about uniform steam temperatures by hand control or automatic means.

STATIONARY BOILERS

In the stationary field, many of the new boilers supplied since this war began have been exact duplicates of, or similar to, units already designed and in operation. This is in contrast to the changes and developments that have been the general practice, especially in the utility field, during the past twenty years.

Under war conditions it has been necessary to obtain delivery as quickly as possible. By duplication of units, drawings and bills of material from other jobs were ready to permit the immediate placing of orders for steel.

The principal exception to this has been in connection with the synthetic-rubber program which became active in April, 1942. At first the program was for 15,000,000 to 20,000,000 pounds of steam per hour, with steam pressures from 350 up to 900 psi for different jobs, and steam temperatures not over 700 to 750 F, using as high as 90 per cent make-up water. Plants

Presented at a joint meeting, Toronto, Canada, Sept. 30-Oct. 2, 1943, of The Engineering Institute of Canada and The American Society of Mechanical Engineers.

were to be located throughout the country with varying conditions of feedwater and fuel; the latter ranging from low-grade coal to oil or gas.

The critical situation of steel supply was becoming apparent to those in charge of this program, and it was suggested that boilers of the forced-circulation type be used as a means of saving steel. After a thorough discussion of the problem, it was found that the saving in weight of steel was about 11 per cent of the boiler unit itself. The actual experiences with forced-circulation boilers abroad were known to have been under different conditions from those to be faced here, so it was considered best to install practically all boilers for this program of proved types of natural-circulation design, with special consideration being given to the adverse water conditions. The equipment actually purchased has a total capacity of 13,080,000 pounds of steam per hour and includes only one boiler of the forced-circulation type, and this has a capacity of 350,000 pounds per hour.

There were three other developments in connection with steel supply that might be mentioned. First, on June 19, 1942, the A.S.M.E. Boiler Code Committee sanctioned the use of a somewhat lower factor of safety for welded-steel boiler drums and seamless steel tubes, but with improvements in design. Although many of the boilers on order had to be built before it was possible to take advantage of this weight saving, later jobs were built to comply with this easement. While the saving in steel was not large on the entire rubber program, it amounted to a considerable saving in all boilers installed for all purposes because practically all stationary water-tube boilers built since that date have been constructed to comply with this easement.

The second development was the almost universal use of large two-drum boilers instead of the three-drum and four-drum types which previously had been generally used for medium- and low-pressure service and in plants using relatively poor feedwater. The two-drum boiler came into general use for smaller sizes in the industrial field during the thirties. It was only necessary to extend this general type of design to the larger capacities, and boilers of this design were supplied for many of the synthetic-rubber plants. These designs were only possible because of the recent developments in steam and water separation in boiler drums, previously mentioned.

The third factor was the design of low-head bottom-supported boilers of large capacities, in many cases for outdoor installation, which were adopted primarily in the interest of saving structural and building steel.

In some processes for the manufacture of butadiene, steam at about 25 psi is heated to 1400 F. Several different designs of superheaters have been developed, some using 6-inch-OD tubes with about $^1/_2$-inch wall, subjected to direct radiant heat of moderately low-temperature gas burners, and others using 2-inch-OD tubes about 0.2 inch thick and subjected only to gas having a temperature of less than 2000 F. Most, if not all, of these superheaters used tubes and headers of 18–8 chrome-nickel alloy. These units are only now being placed into service and results from their operation will be an interesting contribution to our engineering knowledge.

The shortage of certain critical materials has, in some cases, led to changed designs of superheaters and superheater supports to minimize the content of chrome or nickel in alloys used.

Many heating plants have been built throughout the country at cantonments and ordnance plants. In the beginning of the defense program, some of these plants were overengineered as to number, size, and type of equipment, and many of them that should have been suitable for burning coal were designed for oil fuel.

Many industrial plants have converted from oil to coal. Engineers who were foresighted enough to have selected boiler units which were suitable for burning either oil or pulverized coal had little difficulty in making the change promptly and effectively.

Engineers who had made no provision for coal when their boiler units were originally installed encountered considerable extra expense for conversion and often had to be satisfied with a reduced steam output with coal firing.

In making conversions from oil to coal, many plants installed small stokers, and some hand-fired equipment. For the larger units, pulverized coal was usually adopted as fuel. To adapt pulverized coal to small furnaces, either under steam boilers or metallurgical furnaces, a circulating system has been developed in which a single direct-fired pulverizer supplies several furnaces, each taking its fuel supply from a fuel and air pipe much the same as gas is taken from a header.

MARINE BOILERS

This war has definitely proved the wisdom and foresight of the officers of the United States Navy who were in charge of the Bureau of Engineering, later the Bureau of Ships, over the last ten or twelve years.

We are fighting this war with a Navy powered with water-tube boilers and geared steam turbines operating at 600 psi and 850 F, having ample power for high speeds, great maneuverability, lighter weight, greater steaming radius, and a fuel consumption appreciably less for the same class of service than in any other Navy in the world, or our own pre-1935 standard.

At the same time our Navy is doing further experimental work on forced-circulation boilers using steam at still higher pressures and temperatures. One such ship is in service.

In the Merchant Marine, all boilers recently built for the Maritime Commission have been water-tube boilers, usually built for steam conditions of 450 psi and 750 F. These boilers have been moderately rated for the purpose of obtaining great reliability and high thermal efficiency.

An illustration of the trend that may take place in propulsion plants afloat, as increased emphasis is placed on fuel economy, is the 1200-psi reheat steam cycle installed in the S.S. *Examiner*, which went into service about 18 months ago. As it was not desired to use alloy steam piping and fittings, the temperature of both the primary and reheat steam was limited to 750 F. The results to date with this installation have been highly satisfactory; the oil consumption averaging 10.3 per cent less than that of a sister ship fitted with a 425-psi, 750-F steam-turbine installation without reheat. No more difficulty has been experienced with the practical operation of the reheat-cycle installation than with lower-pressure installations.

Boilers of the Navy and the ocean-going Merchant Marine of the United States have all been oil-burning. Continued development and tests of oil burners have been carried on toward the goal of smokeless combustion and high efficiency.

Another important fleet of steamships in war service is carrying coal, iron ore, and other commodities on the Great Lakes. Here again the foresightedness of shipowners resulted in advanced and reliable designs of steam plants before the war, so that they have been able to carry record tonnages per season with great reliability and economy.

Practically all new turbine-driven Lake tonnage is coal-burning and uses water-tube boilers generating steam at 400 psi and 750 F temperature. Coal is usually burned with stokers, mostly of the spreader type. Because of the difficulty of obtaining turbines for some of the newest tonnage being built on the Lakes, a large percentage of these ships are being fitted with reciprocating steam engines using steam at 200 to 250 psi and approximately 450 F total temperature (approximately 50 F superheat).

The war has not disclosed any inherent weakness in any of the marine steam plants that has necessitated any appreciable change or improvement in the equipment which was supplied or is currently available.

Some ten years ago, the floating power plant *Jacona* was built

by installing a 20,000-kw steam turbine in one of the old Shipping Board hulls. It was not self-propelled but was intended to be towed to any location where local or emergency power requirements justified its use. The results obtained with it have been so satisfactory and the flexibility of its location such an asset that four new floating power plants are now under construction for the United States Government for use on inland waterways or the Gulf Coast. New barges have been built to hold the 30,000-kw plants of these four units, these being limited in their dimensions and draft so that they may readily pass through the locks of the inland waterways and shallow rivers. The steam conditions on the *Jacona* were 400 psi and 700 F total temperature, whereas the four new units will use steam at 900 psi and 910 F.

FUEL

This war has brought into bold relief the true situation of the reservoirs of our basic fuel supplies.

For years many companies have blissfully developed power and heating equipment which required the use of high-grade fuel without giving too much consideration to the long-range welfare of their customers and the nation, regarding the reliability of the supply and the probable price of the necessary fuel. The petroleum industry balanced its production in the most advantageous way as long as it could find a market for residual oil at a price competitive with coal.

I believe Harold L. Ickes[1] has presented this picture more convincingly than anyone else has done to date. For a long time it has been evident to many engineers that fuel-burning equipment should be installed in certain geographical areas to use either coal or oil. Many of those who provided only for oil are now burning a fuel which is, at present, partially subsidized by our federal government.

The petroleum industry is now requesting a substantial increase in the price of crude in order to stimulate discovery of new oil fields. Unless substantial discoveries are made, we may shortly be forced to import oil from abroad, and probably also make it from coal and oil shale. Any source of additional oil supply will probably result in a sufficient increase in the price of petroleum products to cause a long-time readjustment of the relative economies of oil and coal for many uses in some parts of the country.

[1] "Coal's New Horizons," *Coal Age*, April, 1943. "Fightin' Oil," Alfred A. Knopf, 1943.

FUTURE

In steam-power equipment we have already passed through a period of striving for the highest thermal efficiency, and more recently we have balanced off on an over-all economy, considering investment, thermal efficiency, reliability, and operating and maintenance costs. At least, that is what we have striven for, but some of these cost factors do not average out in their true proportions until the plant has been operated for several years. Sometimes the cost statistics and operating care have not been truly comparable, so that concrete and accurate conclusions are not always available.

If the price of fuel and the price of equipment are to change materially, future designs will still have to be made on a basis of estimates and judgment.

It seems safe to say that we shall probably burn a larger proportion of coal, and that of a lower quality than we have used in the past.

Steam pressure will depend upon many factors for each individual case. Many power-boiler units installed in the past five years have been for generation at 900 psi and higher. Satisfactory operation of natural-circulation boilers up to 2500 psi has been established.

As to steam temperature, it also depends upon conditions, one of which is the steam pressure. Many plants have been operating satisfactorily at 850 to 950 F, and it is likely that steam temperatures will be further increased as the most effective means for obtaining efficiency at a reasonable increase in cost.

PRECISION OPERATION IN MANUFACTURE OF CUTTING TOOLS AT PLANT OF FISHER BODY DIVISION OF GENERAL MOTORS
(Milling the end teeth of a straight-shank end mill.)

WEAPON MAINTENANCE *in* BATTLE

By BRIGADIER GENERAL E. E. MacMORLAND

DEPUTY CHIEF, FIELD SERVICE DIVISION FOR PLANNING, AND HEAD, MAINTENANCE BRANCH, ORDNANCE DEPARTMENT, U. S. ARMY

THE other Sunday afternoon I listened to a short-wave broadcast from the battlefields of Sicily that vividly brought home to me, as I hope my telling about it here will bring to you, the essential elements of armament maintenance in battle.

The purpose of this battle-area broadcast was to impress upon the American people at home the importance of their continued donations of blood that the lives of gallant men wounded in battle might be saved.

Within the sound of guns and sometimes actually under fire, men of the Medical Corps were administering blood plasma to dangerously wounded soldiers. This plasma came from the blood bank to which all of us have contributed. The fact that it was your blood and my blood which was saving lives of Canadian, British, and American soldiers brought the subject of maintenance into the realm of human understanding more vividly, I believe, than could be possibly done if the telling of the story of maintenance revolved around only the inert elements of machinery, tools, and spare parts.

Of course this story about maintenance of life upon the battlefield concerned men who were possessed of the knowledge and the instruments with which to do their work, but most of all it concerned another element, the blood bank which was under their control and from which they could draw the precious revitalizing and life-prolonging plasma. It was not the men alone, or the instruments alone, or knowledge alone—or even the three combined—which prolonged life. It was that fourth and essential element, the plasma from the blood bank which the men with knowledge and possessing the proper instruments could draw, that made possible the job of maintaining the human body on the battlefield.

THE ORDNANCE "BLOOD BANK"

I wish you would think about that for a moment because I have an analogy to draw. Think about those four great essentials for prolonging life—blood, instruments, men, and knowledge. Yet, however important and indubitably might men, instruments, and knowledge be bound together the great essential element was the blood bank held at the necessary supply level determined by the flow of plasma into the human organism.

In that I see the analogy to the United States Army Ordnance system of weapon maintenance in battle. Substitute spare parts for blood plasma, substitute tools for medical instruments, substitute damaged weapons for wounded soldiers, and add the trained men—really Ordnance doctors—with knowledge, and you have the elements for weapon maintenance in battle.

Eliminate control of the blood plasma from those capable of administering it and the soldier will die; eliminate control of spare parts from those upon whom weapon maintenance depends and the weapon does not go back into the firing line as quickly as it should and men also die.

There is quite a parallel between how the United States Army regards its men and its weapons from the first echelon of preventive health measures and preventive maintenance of weapons up through each of the higher echelons. In each echelon Ordnance regards, as its prime responsibility above everything else, the maintenance of weapons so the men may fight.

The subject which I was given to discuss was "Weapon Maintenance in Battle." There is relatively little weapon maintenance in actual battle. Of course there is some, but the major maintenance is carried on in the combat zone—that fluid area immediately behind the battle line into which the United States Army disposes Ordnance maintenance and supply units under single control in the service of the combat troops. More accurately my subject should be redefined as "Weapon Maintenance in the Combat Zone."

In this mechanized war we should not think too narrowly about weapons as being only guns. The motor vehicle which transports troops and supplies and the prime mover that hauls the guns is as much a weapon in our modern army as is the gun itself.

MOTOR VEHICLES INCREASE MAINTENANCE PROBLEM

In all armies and in all wars the care and maintenance of guns has been the responsibility of Ordnance officers. It is only in this war that the motor vehicle with its diversity of mechanical problems, its multiplicity of spare parts, and the interchangeability of parts between different makes of vehicles that any new problems of maintenance have been injected into war. True, guns have become more complex, fire-control instruments are more intricate and delicate, but the spare-parts and maintenance problems for guns have not been as serious as the maintenance problems for automotive equipment. It is the conversion of the peacetime motor vehicle into a weapon of war, whether it be truck, tank, or half-track, that has really made the maintenance problem in all armies a major headache.

The United States Army recognized early in this war that the motor-vehicle problem had to be solved if we were going to fight successfully. Perhaps we did this as early as we did because we are an automobile-minded people—a nation where once it was promised there would be two cars in every garage, and we came pretty near fulfilling that promise.

HOW SUPPLY AND MAINTENANCE TROOPS ARE ECHELONED

An understanding of the Ordnance plan of supply and how maintenance troops are echeloned in theaters of operation is important. The plan grows directly out of combat necessity. The soldier at the firing line has to be a good marksman; he need not necessarily be an expert mechanic and he will have little time for repairs. In the combat zone, directly to the rear, an expert mechanic is needed, but he need not necessarily be an expert marksman. Between these two will be several degrees of ability.

The prime objective of the men in the front line is to advance, not to repair. In order to get around quickly they must have a minimum of impedimenta. They are interested in guns that will shoot and vehicles that will transport. Here they apply the Ordnance lessons of preventive maintenance. When either gun or vehicle fails they are intensely interested in getting it

An address delivered at a luncheon during the joint meeting, Toronto, Canada, Sept. 30-Oct. 2, 1943, of The Engineering Institute of Canada and The American Society of Mechanical Engineering.

fixed, but by the time it breaks down, it is sometimes too big a job to fix on the spot.

An individual tank in the firing line has its tools along with it. Where there is a company of tanks, perhaps eighteen of them, the company has a pool of spare parts, tools, and equipment and good mechanics. Farther back, servicing more tanks, are battalions with larger pools of spare parts and more specialized mechanics. Still farther to the rear is the Division, which has an Ordnance Company which is as mobile as the Division. Being mobile they must be limited in equipment, but they are depended on to make unit replacements from their own spare-parts supply as far as possible. Then behind the Divisions are the Corps Ordnance troops which are more or less mobile. Still farther back are the Army Ordnance troops, semimobile, which can be moved, but movement must be done by shuttle. On to the rear are the Ordnance bases, veritable arsenals. Here is the big reservoir of spare parts, and great specialization is possible, in both men and tools.

These echelons of assigned responsibilities, based upon parts, equipment, and allowable time, which in turn is a factor of mobility, tend to merge somewhat in practice, depending on the situation. The front echelons will undertake heavier jobs when they are idle than when they are in the midst of battle, but the echelon system always acts as a cushion.

The plan calls for the combat troops to use Ordnance maintenance and supply personnel to the maximum advantage. About five per cent of the total military strength of the Army is allowed for accomplishment of Ordnance supply and maintenance in the field, so every Ordnance man and his tools and equipment must, and does, operate in the most efficient manner to serve the greatest possible number of troops from his own controlled supply of parts.

To accomplish this the United States Army pools Ordnance field personnel into as large organizations as practicable, considering the mission of the troops being served. This pooling has important advantages. The bigger the pool the more it is possible to specialize the individuals in it. Furthermore, spare parts and equipment are saved in pools instead of being frittered away.

A typical Ordnance company is a composite organization consisting of several functional sections and able to handle all types of Ordnance repair. It also has administrative and supply sections. These supply sections, which are the "blood bank" of Ordnance maintenance, can furnish the needs of the troops directly, without requiring the maintenance sections either to get in contact with higher echelons or to call upon another service for their supply. Ordnance would no more consider the separation of supply of spare parts for replacements from its maintenance company than the medical man would consider separating his blood bank from his hospital and installing it in the five-and-ten-cent store down the street.

You will recognize that our Ordnance impetus of maintenance is from the front to the rear and the impetus of supply from the rear to the front with the heavier and less mobile supplies, in greater quantity, being stocked toward the rear where the heavier repairs are made. Nowhere along the line is the blood bank of supplies separated from the men who have the tools and the know-how. Plans of organization change under the stress of combat experience; but there has been nothing developed from the experience of battle that has justified the separation of control of spare-parts supply from the maintenance activities.

There are two problems in maintenance, one if the troops are advancing, and the other if they are retiring. If forces are advancing, combat commanders press every advantage, consolidate new positions, advance, and leave upon the field such equipment as may require repair. If, on the other hand, the forces have met with reverses and are being pushed back, the attempt at repair or maintenance of weapons during an evacuation under pressure would tend only to impede the movement.

AN EXAMPLE FROM THE BATTLE OF TUNISIA

The latter was particularly true in the second phase of the Battle of Tunisia in which the Second Corps of United States troops met its first reverse in January of this year. An enemy force of material strength in armor, infantry, and artillery had captured Faid about fifty miles northeast of Gafsa at which point the Second Corps was attempting to push through to a junction with the British Eighth Army advancing up the coast. We were forced to evacuate Gafsa after the enemy attacked through Faid Pass, took Sidi-Bon-Zid, Sbeitla, and Feriana, and later overran the Kasserine Pass.

During all this time, the Ordnance depot supply companies and the maintenance companies were never separated by any great distance, although they were unable to do any material amount of maintenance work.

The situation was stabilized when a British Armored Brigade arrived and joined one of the U. S. Infantry Divisions and our artillery and shot it out with the enemy's armored spearhead in a decisive action. The recession of the enemy through Kasserine Pass began.

Our troops were not in a position to engage in intensive pursuit operations. One of our armored divisions and one infantry division faced major problems of re-equipment and reorganization. Battle losses included a considerable number of major items of Ordnance equipment. Ordnance Service now faced a supply and maintenance crisis of staggering proportions in the combat zone rather than in the battle zone. More than 1300 major items had been lost, not to say anything of the damage to other equipment. To overcome this condition the movement in the combat zone involved keeping the supply units with their depot stocks of spare parts in constant contact with the maintenance units—the men with the know-how and the tools always close to the blood bank and under the same authority. They must not be separated. Also, supply contact with the zone of communications is essential with central control maintaining consolidated stock records. It is a firm link between men with the know-how and the tools and the depot companies with a blood bank of parts replenished from advance bases.

The engagement of which I have spoken was a retreating operation with quite a different problem of maintenance from those which were to come later when the British and Americans drove the enemy into Cap Bon and final annihilation. The reason I mention this particular situation is because it lends emphasis to the co-ordination of movement of supply and maintenance companies for what obviously was to come. If this phase of the battle had not ended by requiring a regrouping of the forces but on the other hand had turned into a continued action with our engaging in pursuit operations through Kasserine Pass, it would have been even more vital to keep supply and maintenance together.

The importance of the control of the blood bank of spare parts between phases of an engagement must not be overlooked. The Ordnance supply and maintenance units not only had the job of rehabilitating the Second Corps' damaged equipment but it had to draw upon its resources for whatever the next phase of the battle might be.

It is hardly necessary to detail the problem involved in the refitting of the Second Corps, but it is important to bring out how essential it is that the control of spare parts be under a single jurisdiction so the correct balance will be maintained between the refitting requirements and the new supply problem for the next phase. With divided control over supplies the inevitable conflict arises as to which is the more important—to draw upon the parts for maintenance or to draw upon them for the supply of the forces in the next phase. It appears obvious that the rehabilitation of damaged equipment is the more important because another phase of battle is impossible unless the equipment is in shape to enter the engagement. However, with

(*Continued on page 780*)

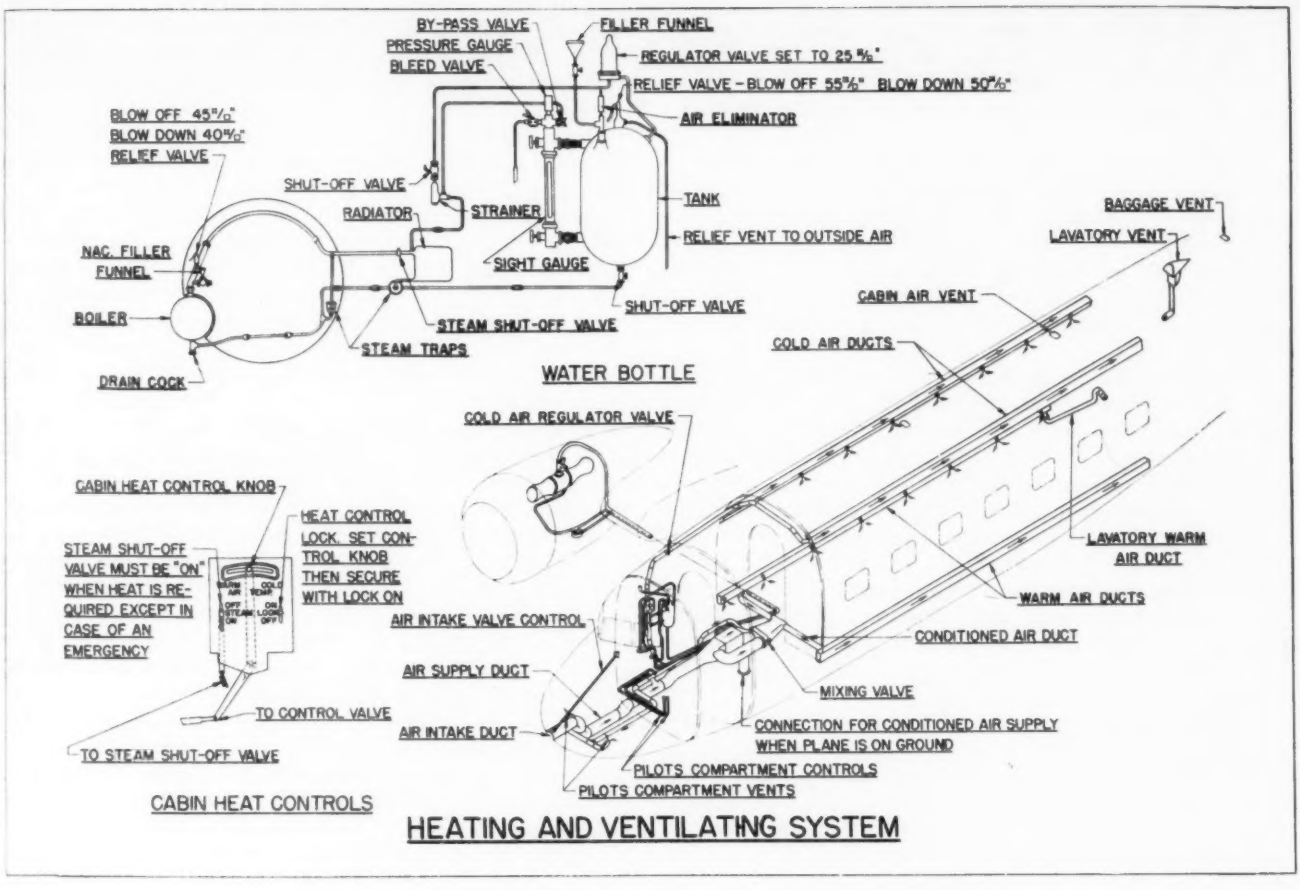

FIG. 1 SCHEMATIC DIAGRAM OF AN AIRPLANE STEAM-HEATING SYSTEM

AIRCRAFT HEATING SYSTEMS

A Critical Comparison of Three Types of Heaters

By WILBUR W. REASER

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THE present-day extensive use of airplanes in the bitter cold of the Far North and upper reaches of the troposphere has made the airplane heating system of prime importance. Heretofore, an airplane-cabin heating system, although required to conform to certain specifications, was usually relegated to any space remaining after other equipment was designed. This attitude in peacetime was understandable since much of the other equipment on the airplane would not function in extremely cold weather. Consequently, the airplane remained on the ground. The high-altitude flights were of such short duration that the crews did not protest the cold. In contrast, wartime flying has proved that airplanes are not effective unless they have adequate heating systems. Airplanes must be able to operate in all parts of the world the year round, and no longer are missions in the troposphere a matter of minutes but of hours.

AIRPLANE CHARACTERISTICS IN RELATION TO HEATING-SYSTEM DESIGN

Before the various parts of an airplane heating system can be designed, the following six properties of the airplane must be ascertained:

1 The type of airplane, that is, a bomber, pursuit, transport, or other type. Since these types vary in their insulation, their heat requirements will likewise vary. For example, less heat will be transferred through the walls of a heavily insulated airplane, and the occupants will require less heat because of a lower heat loss by radiation.

2 The speed for best climb of the airplane. This speed is selected because it gives the minimum pressure supplied by the forward speed of the airplane. Duct sizes are determined from this speed.

3 The maximum cruising speed of the airplane. Additional heat will be required for heating ventilating air, since the air volume will increase almost directly as the airplane speed.

4 The maximum diving speed. High enough pressures may be created in high-speed diving to cause failures within the duct systems. This pressure may be as large as 4 times the cruising-speed pressure of the airplane.

5 The maximum altitude at which the airplane will operate without a large reduction in its performance.

6 The horsepowers of the engines if the exhaust gases are used as a source of heat.

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The proposed temperature rise of the air must also be selected prior to making the heating-system design. This rise is made as high as the materials in contact with the heated air can safely withstand. The Douglas Aircraft Company employs a rise of 300 F.

Specifications in the past have required a certain temperature to be maintained within the airplane for a given outside-air temperature. It has been found that even though the temperatures specified were maintained, the occupants of the airplane were still uncomfortable in cold weather. This phenomenon which is a result of heat loss by radiation from the occupant's body to the cold walls of the airplane has often been overlooked.

It is possible to calculate the skin temperature of the body of an average man for an actual flight condition. This has been done by treating the body of a man as a cylinder 5 ft 8 in. long and approximately 13 in. in diameter.[1] During a test flight it was noted that a ceiling-distribution system gave the occupant a much greater feeling of warmth than did a floor-distribution system, although the outside temperature was 20 F and the inside of the cabin was 80 F in both cases. The floor system created a velocity of air only over the occupant's feet. In contrast, the ceiling system forced warm air at 8 fps around the occupant's entire body. When the ceiling system was used, it was calculated that the man's skin temperature was raised from 94.3 F to 96.3 F.

In addition to heating airplane cabins, heat is being used for preventing and removing ice from windshield surfaces, the leading edges of the wings, and empennage surfaces. This makes it possible for airplanes to fly in all kinds of weather, whereas in the past they have been grounded when severe icing conditions existed. Information on heat deicing methods cannor be divulged because of military restrictions.

The three heating systems used today on airplanes manufactured by the author's company are the steam, the exhaust hot-air, and the combustion types.

STEAM SYSTEM

The steam system consists essentially of a boiler and a radiator or condenser over which the cabin ventilating air passes to be heated. The boiler is supported in the exhaust pipe by lugs. Two corrugated cylinders are assembled so that there is a circumferential gap between the corrugation crests of the cylinders. A steam dome on top of the boiler collects the steam generated as the water passes through the gaps from a water sump on the bottom. The steam is piped to the upper part of the radiator where it is condensed, giving up its heat of vaporization to the ventilating air. The condensate is piped from the bottom of the radiator to the boiler. The remainder of the system consists of a water tank, safety valve, pressure regulator, steam strainer, and piping. The function of the water tank is to act as a surge chamber within the system. The pressure of the system is controlled by regulating the pressure of the steam entering the top of the water tank.

A set of mixing valves on the air-discharge end of the radiator controls the quantity of heat produced. One of the valves is connected to the radiator and the other to a duct which conveys cold air around the radiator. A shaft, controlled from a quadrant in the cabin, operates the valves in such a manner that when one is closed the other automatically opens.

The operating principle of the system can best be understood by following the schematic diagram shown in Fig. 1. The hot exhaust gases from the engine evaporate the water, the steam passing to the radiator. From this same line, piping supplies steam to the regulator which maintains a given pressure in the upper portion of the water tank. From the base of the tank, a tube "tees" into the line connected to the discharge pipe of the radiator. A single line then returns to the lower side of the boiler. When the hot-air mixing valve at the discharge side of the radiator is opened, air passes through the radiator. Next, the steam condenses, giving up its heat of vaporization to the ventilating air. Consequently a drop in pressure follows on the steam side of the radiator. Steam from the boiler will then flow to the radiator causing a pressure drop within the boiler. As a result, more water flows into the boiler. On the other hand, when the hot-air mixing valve is closed, the radiator no longer condenses steam. Therefore there is a steady pressure in the boiler which forces the water back into the surge chamber. When only a small quantity of heat is needed in the cabin, the water surges within the water tank, intermittently allowing some water to flow into the boiler, chilling it and causing severe stresses.

In the duct system, a tube containing the nose valve at the entry brings the cold air from the nose of the airplane to the face of the radiator. A duct by-passes a portion of the air around the radiator and through one of the mixing valves previously described. The cold and hot air from the two mixing valves is then channeled into a common duct and conveyed to the fuselage distributing system. As the boiler has insufficient capacity to prevent the radiator from freezing, the pilot can partially close the nose valve when flying in extremely cold weather. An automatic control connected to the mixing valves has been designed which will maintain air at a predetermined temperature. If successful, this automatic control will preclude the necessity of having a nose valve.

Boilers in the past have had very short lives as the inner muff shell collapsed when made of material sufficiently strong to resist the buckling stress. This difficulty is being remedied by replacing the inner shell of the muff with a thinner material which is corrugated to withstand the steam pressure. It was believed that the buckling was caused by stresses created by the temperature gradient across the inner shell. To test this belief, a gas burner was mounted inside one half of a cylinder the same diameter as the inner shell of the muff. Water was poured at intervals on the outside of the shell. After a short time, the inner shell buckled just as it had on the boilers in service.

An investigation of the thermal circuit through the shell of the boiler reveals that the resistance to heat flow on the gas side is the controlling factor in preventing the transfer of heat from the gas to the water. As in an electrical circuit where the larger the resistance, the greater is the drop in voltage, so in the thermal circuit, the larger the resistance, the greater is the temperature drop. That is to say, when the boiler is generating steam at full capacity, the metal temperature will be only a few degrees higher than the temperature of the steam. This reduction in metal temperature should insure a longer boiler life.

To maintain steam generation in the boiler, the radiator must be continually condensing steam. A dump valve is being constructed to release the heat overboard from the radiator when it is not needed in the cabin.

These two changes in the system have not been fully developed since the tendency has been to discontinue the use of the steam system. Although this heating method can be made to work very well in the air, operational difficulties have been encountered on the ground where there are no heated hangars to shelter the airplanes. Another major disadvantage of this system is its weight, which amounts to about twice that of the exhaust hot-air type and about four times that of the combustion type of heater.

It might seem that with all of the disadvantages of the steam system it would not be worthy of further consideration; yet, when the future air liner is considered, the steam system may also have advantages. It is well known that air contains considerably less moisture at 20,000 ft than at sea level. Consequently, moisture will have to be added to the cabin air to insure passenger comfort when flying at high altitudes. This

[1] "Heating, Ventilating, and Air Conditioning Guide," The American Society of Heating and Ventilating Engineers, New York, N. Y., 1943, p. 54.

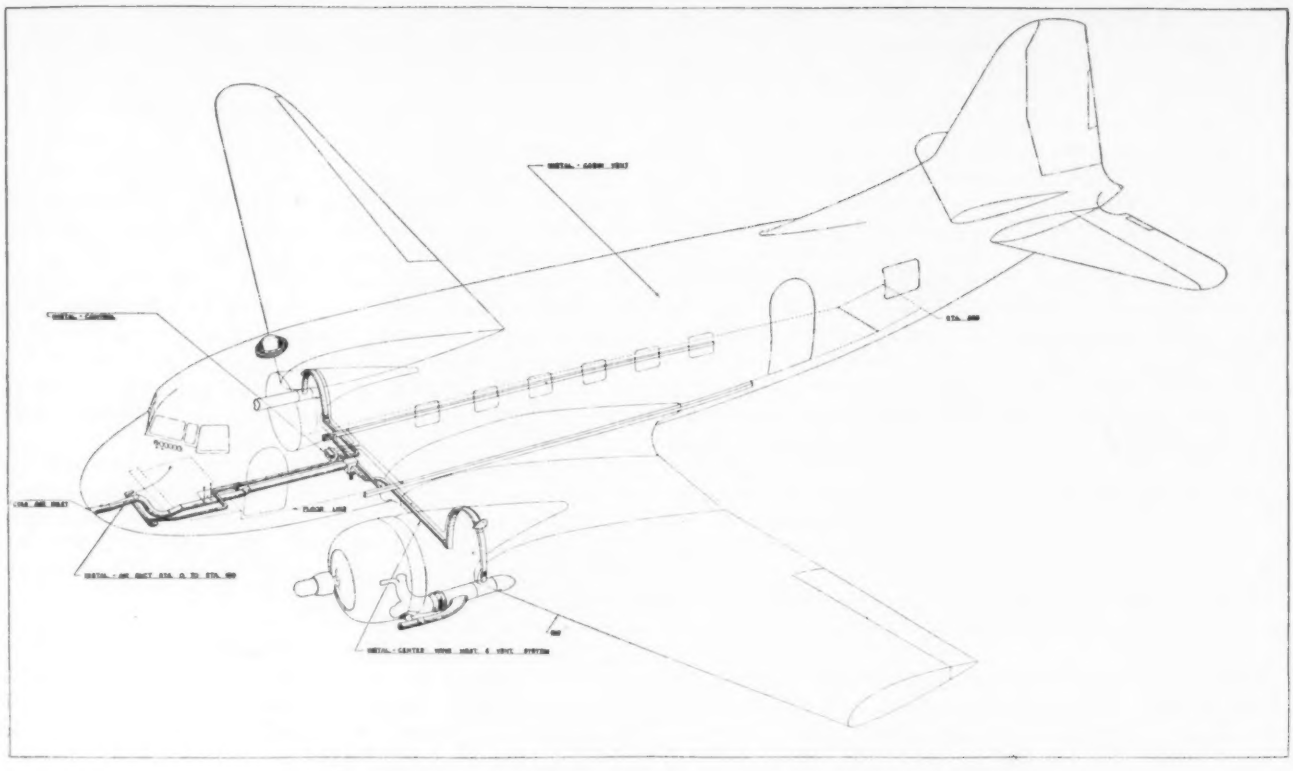


FIG. 2 PRODUCTION ILLUSTRATION OF AN EXHAUST HOT-AIR-HEATER SYSTEM

could easily be accomplished by spraying steam into the ventilating air. A method has been developed by which water can be reclaimed from the exhaust gases. Since there is approximately 1 gal of water in the products of combustion for 1 gal of gasoline used, it can be seen that there is an abundance of water for humidification. Another advantage which adds to the desirability of the steam system is its extreme safety. There is no need for safety devices to prevent toxic gases from entering the ventilating-air stream.

EXHAUST HOT-AIR-HEATER SYSTEM

The exhaust-hot-air-heater system is considered one of the best systems for use in the Far North because there is always heat when engines equipped with heat exchangers are running.

This type of heating system consists of an air scoop, a heat exchanger in the exhaust pipe, and a duct system. Part of the duct system carries hot air from the heat exchanger and cold air from an air entry in the nose of the airplane to the mixing chamber in the fuselage. From there, the tempered air is taken to the distributing duct within the cabin. Excess hot air is discharged from the airplane. To heat the cockpit, a duct branches from the main hot-air-supply duct to a mixing valve where it can be tempered before entering the cockpit from a tube near the feet of the pilot and copilot. In the event that an engine is losing an excessive amount of oil, a two-way valve is manually controlled to prevent air contaminated with oil fumes from entering the cabin.

This system at a glance would seem simple, but actually it presents design problems in heat transfer, fluid flow, and heating and ventilation. The heat-exchanger air scoop receives its air from the slip stream of the propeller. The purpose of this air scoop is to deliver the quantity of air required for operating the system with as small a loss as possible of dynamic pressure caused by the forward speed of the airplane. Aerodynamic studies have shown that one size of air scoop is more efficient than any other size for a given quantity of air. In determining this area, the velocity to give the best scoop performance is taken as equal to 0.6 of the free-stream velocity of the airplane. Since this is a high velocity, the air must therefore be retarded by expanding the duct carrying the air to the heat exchanger. The air scoop projects forward of the engine-cowl flaps to prevent its collecting engine-cooling air which may be contaminated with oil fumes, exhaust gases, and propeller alcohol deicing fumes.

During the past year, several different types of heat exchangers have been developed. These types are (1) extended fin, (2) a single tube passing through the exhaust pipe, (3) extended primary surface, (4) a muff surrounding the exhaust pipe, and (5) a bundle of tubes.

The extended-fin type of heat exchanger is used where there is only a small amount of space available, or where there is a high resistance to heat flow of either the air or exhaust gas. This heat exchanger has a large heat-transfer area for a small volume. Adding more heat-transfer area to a surface having a high resistance to heat flow is equivalent to decreasing the resistance. To make this type of heater light in weight, the fins are either spot-welded or furnace-brazed to the primary surface. This fabrication method does not always insure perfect contact between the fins and the primary surface, making the fins ineffective. Consequently, the extended-fin exchanger has often been heavy in proportion to the amount of heat that it supplies.

The second type of heat exchanger—a single tube which passes through the exhaust pipe—is the most simple of all the exchangers. Usually the tube, approximately one third of the diameter of the exhaust pipe, passes diagonally through the exhaust pipe. The quantity of heat transferred by this exchanger is less than that of the other exhaust-gas heat exchangers, because the over-all heat-transfer factor is nearly the same, while the heat-transfer area is smaller.

The third type, the extended-primary-surface heat exchanger, has only a thin piece of metal between the exhaust gases on one side and the heated air on the other. Since the resistance of the metal to heat flow is negligible, this heater is efficient. The construction is complicated; and although it has not been tested for endurance, it would appear to have a short life. It has a large heat-transfer area for a small volume. Accordingly, a high ratio of heat is transferred in proportion to its weight.

The heat exchanger, shown in the schematic diagram in Fig. 2, is the fourth or muff type which consists of a metal cylinder spaced from the cylindrical exhaust pipe to form an annulus through which the ventilating air passes. The forward end of the exchanger is attached rigidly to the airplane-nacelle structure, while the rear end is allowed to move freely. The portion of the exhaust pipe connecting to the engine is secured to the exchanger with a ball-type joint. This type of joint prevents any movement of the engine from being transferred to the heat exchanger. The ventilating air is supplied at the forward end of the annulus through a flared tube having as great an area and radius as possible. On the rear end, the annulus is enlarged, forming a collector ring to which the supply duct is attached. Over the whole exchanger is placed a thermal blanket and a metal shield to prevent the loss of heat.

The type of airplane shown in Fig. 2 has a long exhaust pipe along the outboard side of each nacelle. In making a design study for a muff, the resistance to heat flow on the exhaust-gas side was found to be higher than the resistance on the air side. The resistance of the air side was determined by the portion of the dynamic pressure of the airplane which could be used as pressure drop through the exchanger. The exhaust pipe was reduced in size until the resistance on the exhaust-gas side was approximately equal to the resistance on the air side.

The fifth type of heat exchanger, the tube bundle, consists of a number of tubes welded together so as to form interstices between them. In some designs the exhaust gases pass across while in others they pass through the tubes. If the exhaust gases or the air have to be turned before entering the exchanger, they should pass across the tubes to give the best temperature distribution. The tube bundle gives good service life as well as a high rate of heat output for little weight.

The ducts that carry the hot air from any of the different types of heat exchangers to the mixing valves have irregular shapes. Generally the shapes change from a square cross section to a circular, or vice versa. Often duct turns are sharp and must be vaned to prevent excessive pressure drops.

The amount of heat loss by convection, conduction, and radiation through the ducts has to be predicted in order to determine the amount of insulation, if any, that is to be used. Insulation for ducts should be light in weight, low in thermal conductivity, fire-resistant, and resilient to prevent crushing while handling. As yet, there has been no insulation found to meet all these requirements.

The mixing-valve assembly consists of three butterfly valves, one for hot air, one for cold air, and the third for discharging the excess hot air overboard. These three valves are interconnected. For instance, when maximum heat is desired, the cold-air valve is closed, the hot-air valve is opened, and the dump valve is closed. When no heat is needed, the cold-air valve is opened, the hot-air valve is closed, and the dump valve is opened, releasing the hot air overboard. Any intermediate position of the valves allows a portion of the hot air to enter the mixing chamber, discharging the remainder overboard.

The tempered air is piped from the mixing chamber into the cabin air-distribution system which diffuses the air into the cabin. To provide for the severe icing conditions encountered when outside-air temperatures range from 0 to 32 F. the cockpit mixing valve furnishes hot air for deicing the windshield without influencing the temperatures in other parts of the fuselage. This valve assembly consists of two butterfly valves, one in the hot-air duct and the other in the duct bringing cold air from the main cold-air supply.

The direct-exhaust hot-air system should have some kind of carbon-monoxide-detecting equipment, since a crack or opening in the heat exchanger would let exhaust gas into the heating air stream. A heavier, but safer, exhaust hot-air type of heating system has been developed which passes the hot air from the exhaust heat exchanger through another exchanger, heating a second source of outside air for cabin distribution. Its primary air may then be released overboard or may be used for empennage deicing.

INTERNAL-COMBUSTION-HEATER SYSTEM

A heater which burns fuel for its source of heat is known as an internal-combustion heater. There are two types currently in use, i.e., the type which burns a primary mixture and the type which burns a secondary mixture. Schematic diagrams of installations of combustion heaters of the primary- and secondary-mixture types are shown in Figs. 3 and 4, respectively. The location in the airplane is the same for either type. The combustion heaters, being independent of the exhaust gases, can be located close to the distribution system of the airplane cabin, thereby removing the necessity for piping heated air from the engines to the fuselage and effecting a saving in both weight and heat.

The first type of heater receives its air-fuel mixture from the carburetor of the airplane engine. Other means of supplying the air-fuel mixture have been either a gasoline-engine or an electric-motor-driven compressor and carburetor. The dynamic pressure of the airplane may also be used to force air through the heater carburetor. The primary-mixture heater burns with a blue flame. The combustion occurs within a short space, making it difficult to transfer the heat rapidly to the ventilating air. In order to keep the metal temperatures low enough to prolong the life of the heaters, an extended-fin combustion chamber is required, adding weight and also increasing the fabrication costs.

The primary type, shown in Fig. 3, receives its air-fuel mixture through piping from the diffuser case of the engine supercharger. The products of combustion are returned through ducts to the intake of the engine supercharger which supplies the pressure differential, thus forcing the gas through the heater. An electrical-resistance coil in the combustion chamber ignites the air-fuel mixture. Ventilating air supplied from a scoop on the outside of the fuselage passes over the heat exchanger and extracts the heat from the hot gases in the exchanger. This heated air is conveyed to a ceiling distribution system in the main cabin and crew's compartment where it is forced down to the floor at high velocity. Foot-warmer outlets supply heat to the cockpit.

The quantity of heat generated is controlled by a butterfly valve in the supply line of the heater, regulating the amount of air-fuel mixture allowed to enter. An electric motor having a manual override controls the heaters. The electric motor is automatically controlled by an amplifier receiving its signal from a cold-air supply, a hot-air discharge, and a cabin resistance thermostatic bulb.

The primary-mixture type of heater has been unsatisfactory in service. As previously explained, the heater has a relatively short life. It often fails to operate because the air-fuel mixture it receives is too rich or too lean. The engine carburetor supplies a maximum rich mixture for high power. It is difficult to design a fitting which takes the same mixture from the supercharger-blower case that the engine cylinders receive. Therefore the heater receives too rich a mixture. For the power required for the cruising speed, the carburetor supplies the engine cylinders with a lean mixture. If the outside-air temperature is below 0 F and the heater air-fuel supply lines are long, a portion of the fuel will condense causing the air-fuel mixture to become too lean. Aside from the trouble with the heater fuel supply, on some types of airplanes the long exhaust lines returning the products of combustion to the engine become clogged with ice when outside temperatures are very low.

The heaters using the primary mixture are being replaced by the author's company with heaters using the secondary mixture, as shown in Fig. 4. This newer type of heater has liquid fuel from the airplane-engine fuel pumps sprayed into the combustion chamber. At a right angle to the position that the fuel

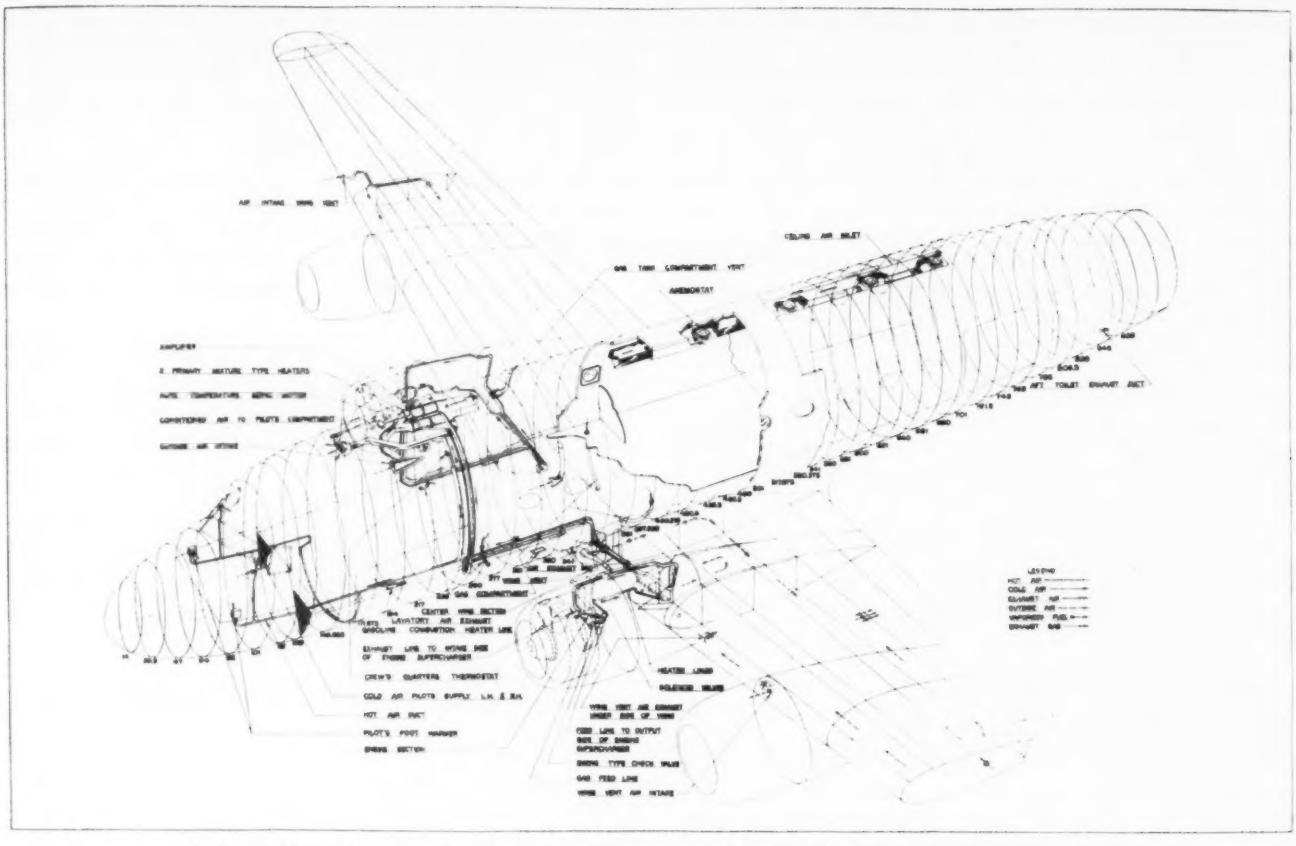


FIG. 3 PRODUCTION ILLUSTRATION OF A PRIMARY-MIXTURE INTERNAL-COMBUSTION-HEATER SYSTEM

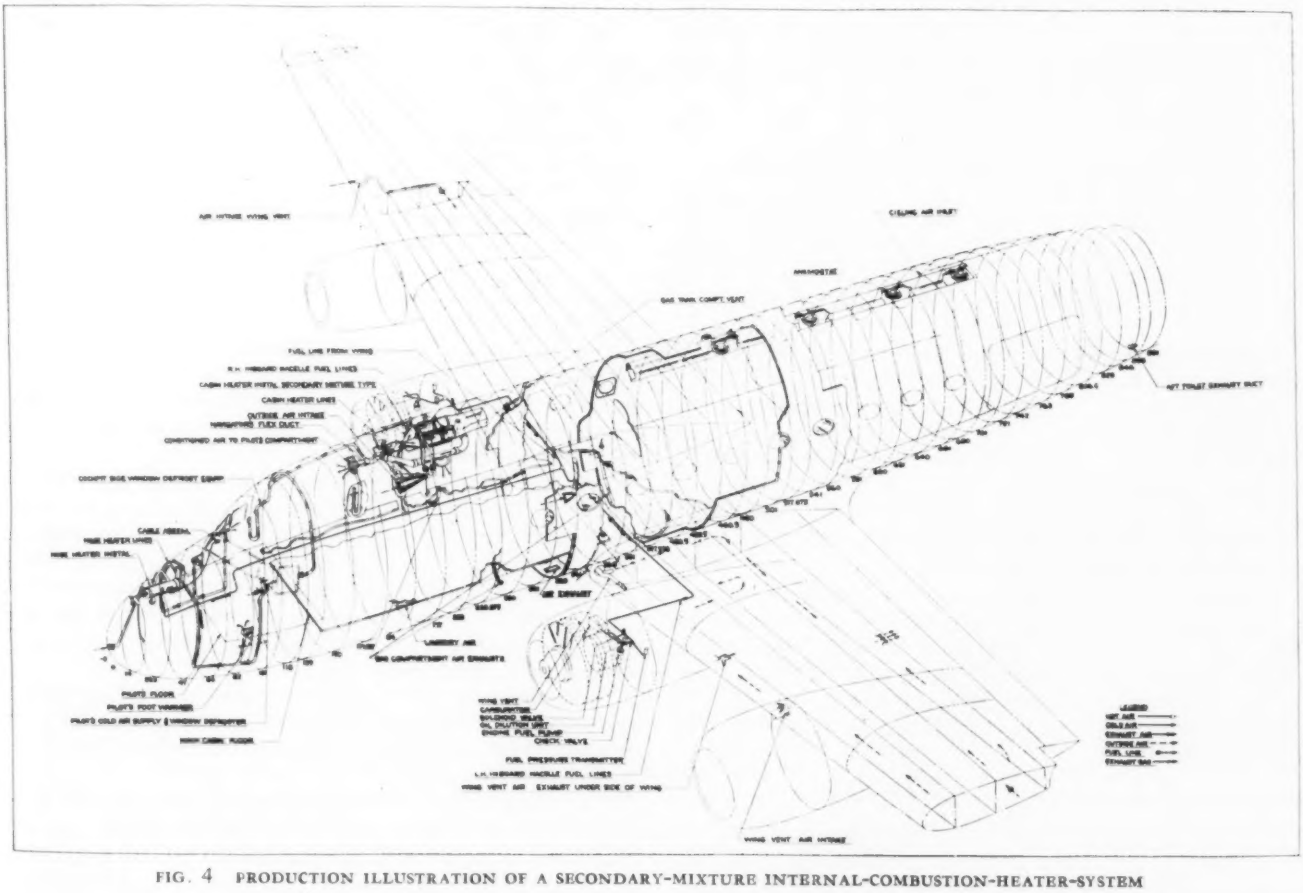


FIG. 4 PRODUCTION ILLUSTRATION OF A SECONDARY-MIXTURE INTERNAL-COMBUSTION-HEATER-SYSTEM

is injected, air from an external scoop is introduced tangentially to the cylindrical combustion chamber. The air, forced by the dynamic pressure of the airplane through an air regulator, maintains a constant pressure drop across the heater. Accordingly, there is a constant weight flow of air, providing the surrounding absolute pressure remains the same. Up to 20,000 ft the change in weight flow is not great enough to change materially the efficiency of the heater. At higher altitudes, the regulator requires an altitude compensator which increases the pressure drop so as to maintain a constant weight flow of air. The air-fuel mixture is ignited either with an electric coil or a spark plug. When a spark plug is used in starting the heater at temperatures below 0 F, an electric preheater is required to heat the fuel before it enters the combustion chamber. The secondary-mixture heater burns with a yellow flame gradually turning blue as combustion progresses down a cylindrical combustion chamber. The heat is spread over a large area making the use of an extended-fin combustion chamber unnecessary.

This heater can be governed either by a modulating or an "on-off" type of control, the quantity of fuel being regulated in either case. The modulating type of control regulates the fuel from 100 per cent of the heater capacity down to 30 per cent. This control is generally used on heaters where only manual control is desired. The on-off control is used where the heaters are controlled automatically. The fuel may flow through either one of two solenoid valves. One of the valves when open permits enough fuel to enter the heater for full capacity. The other solenoid valve has a restrictor which limits the fuel to 75 per cent of the capacity. The automatic control opens and closes either of these valves, depending upon the setting of the selector switch. The automatic control is similar to that used by the primary-mixture heater, with the exception of a smaller amplifier and the absence of the electric motor. A manual switch electrically by-passes the automatic temperature control in case of its failure.

The ventilating air is supplied and distributed in the same way as for the heaters using a primary mixture, except that an additional small heater supplies heat to the cockpit for windshield deicing and for the pilot's and copilot's foot warmers.

Safety switches prevent the heaters from being operated when there is insufficient air for combustion or ventilating purposes; and they shut off the fuel at its source if the fuel-supply line should leak or if it should break. Carbon monoxide cannot enter the heated air because the average pressure on the ventilation side of the heater is higher than that on the combustion side.

With the low pressure drops required for operating the secondary air fuel type of combustion heaters, a small power centrifugal blower electrically driven can be installed as part of the airplane heating equipment. This arrangement makes it possible to heat the airplane on the ground independently of the main engines on airplanes having space for an auxiliary gasoline engine driving a direct-current generator. This additional unit can also be used for supplying electrical power for starting the main engines and hoisting cargo.

In a ground test, the secondary air fuel-type heater, running at its capacity for 1000 hours, was in good condition at the end of the test. Under actual flight conditions, the heater would not be operating at its capacity continually, indicating that its life would be considerably longer. The length of life of this heater compares favorably with that of other equipment on the airplane.

COMPARISON OF HEATING SYSTEMS

A critical comparison of the three types of heating systems has shown that the steam system is heavy, unreliable in freezing temperatures, and requires frequent replacement of the boiler. On the other hand, the system is safe and with improvements in design may be of use in the future for humidifying the cabin air. The chief objection to the exhaust hot-air heating system is the possibility that carbon-monoxide gas may enter the cabin. Yet the system is the simplest and most reliable in cold weather. The fact that the first type of combustion heating system fails to start in cold weather and has a short service life makes it unsatisfactory. However, the second type replacing it employs a different combustion principle which makes it start readily at low temperatures. This heater is light in weight; it has shown long life in a ground endurance test; and with the addition of a lightweight electric-motor-driven fan it will supply heat independently of the engines while the airplane is on the ground.

Wartime flying in extremely cold weather has proved that an adequate heating system is an essential element of an effective airplane, and it has put heavy demands on the system over the heating requirements of peacetime. Better methods of predicting airplane-heating-system requirements and performance are now available for designing more effective systems. Extensive ground and flight testing will further improve these analyses. These factors point the way toward future airplane equipment having a higher heat output and longer life, and being lighter in weight, simpler to operate, and more reliable.

Weapon Maintenance in Battle

(*Continued from page 774*)

divided control, it is frequently the case that the supply officer thinks first of the stocks for the next engagement, leaving the maintenance crews who have to requisition their spare parts to wait until the supply job is completed.

PROCUREMENT OF SPARE PARTS

One important factor in the Ordnance supply-maintenance combination I have purposely left to the last. By so doing I hope it will get the accentuation which it deserves. It is the subject of procurement of spare parts.

Under our Ordnance system spare-parts procurement is based upon requirements determined by Ordnance maintenance records. We believe and practice that the men who do the maintaining are best qualified to determine the supply levels and therefore should establish the procurement factors. It is not, in our opinion, a sound practice to rely upon an authority separated from maintenance either for procurement or distribution.

The end result of all Ordnance procedure is maintenance of all weapons in a condition suitable to the job for which they were designed. To accomplish this end result it is well recognized that there must be no deviation of the factors of parts control anywhere along the line.

The main job of maintenance revolves around the "bits and pieces" rather than the unit replacements. There are more piston rings needing replacement than there are transfer cases; more distributor points than batteries needing attention; more gaskets than engine blocks; and so on through the whole list. It is these bits and pieces which must be procured and distributed in proportion to their usage as determined by the consumer who is the maintenance man.

These bits and pieces represent 85 per cent of the volume of spare parts and only 15 per cent of the dollar value; while the major units represent only 15 per cent of the volume and 85 per cent of the dollar value.

It is the record of maintenance working in close association with supply under the direction of a single Ordnance organization that is making possible the successful job which the United States Army is doing not only in keeping its own vehicles rolling and its guns shooting but sometimes those of the United Nations as well.

Development of POSTWAR AIRCRAFT

By JAMES T. BAIN

SUPERINTENDENT OF ENGINEERING AND MAINTENANCE, TRANS-CANADA AIR LINES

THE subject of postwar aviation has been discussed by almost everyone who can catch anyone to listen to him. Never a day passes without some additional writings on the future centers of global aviation or the wondrous monsters that will be used as operating media.

It is indeed fortunate that there are some shining lights of sound engineering and common sense to safely guide the development of the air-transport aircraft through the amazing welter of words that have been written. One such shining light is the Wilbur Wright memorial lecture delivered before the Royal Aeronautical Society in London by Edward Warner, vice-chairman of the Civil Aeronautics Board. Because of Mr. Warner's lecture, I do not propose to try to discuss the aerodynamics of postwar aircraft, but rather to discuss the subject from my interpretation of the viewpoint of an operator, nor do I propose to enter into any discussions on public service, national prestige, politics, or the well-being of this crazy world's peoples. Aircraft operation is a commercial enterprise that, to progress, must be developed in terms of dollars and cents. The truth is that the best air transportation will sell most easily, so our endeavors for improvement are largely dictated by a need for greater salability.

The stock in trade of air transportation is speed with safety, regularity, and comfort. The speed factor is already sufficiently established to satisfy immediate requirements; comfort is reasonable but can be considerably improved; regularity has not been attained, and the reserve margin of safety is the lowest of any commercial form of transportation. Without much higher standards of safety and regularity, air transportation cannot progress to the vast horizons that have been so prolifically forecast.

NO IMMEDIATE REVOLUTIONARY CHANGES

My discussions today on the form of our postwar aircraft are based on two convictions.

The first is that the basic airplane as we know it today will not undergo any revolutionary structural or size change for a considerable time in the postwar period.

I will briefly outline a few of the factors which I believe support this contention.

Probably the most simple reason is that the only types from which immediate postwar aircraft can be developed are the present military and transport aircraft. With the concentrated effort there is on all sides for war production, the application of sufficient engineering time to develop radically new commercial aircraft is simply not possible. Admittedly one cannot visit any manufacturer's plant without someone's opening a desk drawer and pulling out a preliminary specification of what he proposes to build, but the difference between preliminary specifications and completed aircraft might well amount to four or more years of hard work. The design and construction of a new aircraft is a long and costly business, and associated with it is the mass of detail specifications of items which the aircraft manufacturer himself purchases as completely designed units.

Presented at a joint meeting, Toronto, Canada, Sept. 30–Oct. 2, 1943, of The Engineering Institute of Canada and THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Even if the manufacturers were able to give sufficient time and study to new-type aircraft, from what basis are they to start?

The best heads in the industry have variously estimated traffic potentials at anything between prewar level and astronomical percentages of increase. Each new estimate is made from what appears to be logical assumptions. They can't all be right. One committee sets up a 20-passenger airplane as the most essential requirement and another fellow is planning a 300-ton monstrosity as his interpretation of pressing necessity. The fact is that no one yet knows how postwar aviation will develop. The entire situation depends on the economics of the world reconstruction that will follow the present holocaust. We can't compare masses of population in North America and Continental Europe and make assumptions on traffic potentials based on prewar North American standards of living. It may and probably will take years to justify any volume of transoceanic travel.

In many respects, desires are conflicting. For example on one hand it is known that frequency of flight with small aircraft will give many advantages such as a higher percentage of nonstop flights; flexibility of aircraft disposition and routing; more desirable travel times for the greater number of people and higher percentages of revenue hours flown. On the other hand, there is the desire to provide the spacious comfort of the larger airplane which has all the inherent penalties of lower frequency of service and a smaller percentage of nonstop flights.

The air-cargo picture is still sufficiently obscure so that no one is yet able to determine whether or not mail and air express will be carried in special-type aircraft or carried in regular passenger-service aircraft. National standards of living, cost of aircraft production, disposal of wartime equipment, and hosts of other variables make any estimate of little more value than blind guesswork.

With the evidence that future requirements of aircraft types and sizes cannot be deduced from any existing statistics, I am forced to the conclusion that such intensely interesting developments as flying-wing aircraft and jet propulsion must for the time being be relegated to our research engineers and to the relatively distant future. We are immediately concerned with getting air transportation back on its own feet and essentially this must be done with what we presently have in the line of equipment.

EFFECT OF WARTIME DEVELOPMENTS

Many of us are laboring under the belief that the war has given tremendous impetus to the development of the airplane. This is an illusion from which we must free ourselves. Because of the war it is true that many equipment items have undergone forced growth and will be available after development and adaptation for the furtherance of peacetime commercial operation. Even this benefit may be delayed or destroyed unless we can overcome the problem of disposal of wartime aircraft and equipment without putting the entire associated aircraft-manufacturing industry out of business.

In the immediate prewar period several new transport aircraft were under development and construction. Notably such

manufacturers as (alphabetically) Boeing, Curtiss, Douglas, and Lockheed were developing newer and larger air-line equipment based on specifications compiled in consultation with the commercial operators. The commencement of hostilities stopped the development of these aircraft as commercial types and put an approximate version of them into military garb for the duration. Additionally, the commencement of hostilities drastically altered every air-line operation. Shortage of aircraft has resulted in schedules being run at times dictated by maintenance requirements. There has been no advance in the methods of operation since the war started. The air lines have been "getting by" and it has been a hard struggle to maintain prewar standards. The point I am trying to make is that, at the cessation of hostilities we will, with luck and good government policies, be starting in where we left off at the beginning of the war.

It has been contended that the operations of the various Air Transport Commands have developed transport aircraft, have "taken the bugs out" of the new types. I contend that on the contrary, the job would have been done better and faster by commercial operators. Without the war, the concentration of knowledge that existed in manufacturers' plants and the air lines would have more easily solved shakedown troubles. The operation of Air Transport Commands do have some lessons for us. Their practice of using heavier gross load than is normal in transport aircraft has caused many people to question the validity of present airworthiness strength factors and performance requirements. Personally, I believe that it is essential that we proceed with extreme caution in attempts to revise airworthiness requirements or we are liable to experience a reduction in safety standards that are already not too high.

I would like to give just one more reason why we will have no radical changes in aircraft design for some years to come.

Airplanes such as the Douglas DC-4 and the Lockheed *Constellation* were designed in the prewar years because the air-lines had need for them. Such considerations as (1) improvement of safety standards with four-engined equipment; (2) improved performance and passenger comfort; (3) the probability of all first-class mail being air-borne, and so on, made these aircraft necessary for normal air-line development. Had there been no interruption by war, all the major air lines would presently be flying with these larger aircraft.

The program of purchasing new equipment is the immediate prospect of all air lines as soon as manufacturing facilities are available. The strain on financial resources will be very heavy. It will be impossible to repurchase aircraft with each minor advance in design.

If the costs of air transportation are to be kept down to usable levels, it is only when it is economically better to re-equip than to continue existing aircraft in operation, that an equipment change is possible. From all present indications, this condition will not be reached for a number of years in the postwar era. I personally believe that full depreciation in six years from purchase date will be a reasonable figure.

REVISED STANDARDS OF SAFETY AND REGULARITY NEEDED

So much then for my conviction that commercial aircraft will not undergo any revolutionary changes for a considerable time in the postwar years.

My second conviction is that we have got to revise our thinking regarding aircraft operation and develop new methods to achieve the necessary standards of safety and regularity.

I propose to briefly discuss present practices and attempt to show some possible corrections.

The flight operations of aircraft roughly breaks down into two major functions.

(1) The maintenance and overhaul of aircraft to insure mechanical perfection at all times and

(2) The flight of the aircraft from departure point to arrival at destination.

I am omitting reference to the many associated functions such as traffic, ground communication, and passenger service, because they do not directly affect this discussion.

Taking first the function of maintenance and overhaul, we find that present practices on all air lines broadly follow the same lines.

After certain specified times in operation, each aircraft is removed from service for inspection and what can be called "preventative maintenance work."

The "out-of-service" period varies with the particular inspection or "check" to be made and ranges from a few hours for the frequent daily or "line" check to several days for a major overhaul. I have already referred to the fact that present-day flying schedules are virtually dictated by the necessity of conducting maintenance work at specified times. On the major routes, layover times have been cut to minimums and aircraft are flown continuously regardless of desirable schedule times until removed from service for routine maintenance inspection and adjustment.

In maintenance work the emphasis has always been on airworthiness and no decrease of standard has been permitted. Since the war, the air-line passenger may have had on occasion, some reason to complain about some of the niceties of air travel which have had to take second place. Heating systems, upholstery, food service, and the like, have very correctly been sacrificed in some degree to airworthiness and the maximum number of flight schedules.

In spite of the emphasis given to maintenance necessities, the air lines are fortunate over each year's operation to average 12 hours in service per day per aircraft.

It is very seldom in these days of equipment shortage that spare aircraft are available to cover mechanical irregularities and such minor troubles as defective cowl flaps or spark plugs can cause delays of some hours in scheduled operation. In some cases where trouble shooting is difficult, it may be necessary to cancel the schedule, or if it is available, to ferry a replacement aircraft. In either event, there will be a rushed concentration of highly skilled ground mechanics to correct the defect in the grounded aircraft.

Under the present system, maintenance supervisors are always faced with the problem of the immediate future and very often the only planning and control of work that can obtain has to be made on comparatively speaking "snap judgments."

This roughly covers the picture of air-line maintenance without elaboration on the many shortages of men, equipment, accommodation, and knowledge that presently makes life so complicated.

OVERCOMING DEFECTS IN MAINTENANCE SYSTEM

Present-day aircraft by their nature are extremely complicated mechanisms condensed into small bulk. It is true to say that the manufacturers could have done a great deal more than they have to simplify maintenance and overhaul problems, but in the past, the small voices of the air-line-maintenance mechanics and the factory project engineers have pleaded in vain for a study of maintenance facility. The designers of aircraft have always concentrated on the aerodynamic properties of their products to the almost total exclusion of everything else.

Aircraft now being built are beginning to show that a little more consideration has been given to the importance of ease in aircraft maintenance, but the optimum cannot be obtained with most of the types of construction being used and it will continue to be virtually impossible to make every individual component easily replaceable and accessible until suitable construction methods are adopted.

I would like to present some suggestions which I believe will make it entirely possible to overcome some of the major defects in our present system of maintenance and overhaul.

The war has taught the aircraft manufacturers a great deal about what can be called "unit" construction of aircraft. The conservation of floor areas and the necessity of subcontracting major portions of their finished products have developed accurate jig and tool work in the fabrication of aircraft in sections. During final assembly the many sections are brought together and made up into a single complete unit.

With a little care in design and an understanding of the operator's requirements it should be possible to construct an aircraft from similar sections to those presently being used but having the major difference that they can be subsequently disassembled from the complete aircraft with ease and rapidity.

As an example of what I mean it should be possible to remove the entire tail unit of an aircraft complete with fins, rudders, elevators, and their controls in a period of 15 minutes and replace a similar unit in a similar period of time. Power plants should all be exactly alike and quickly replaceable by simply disconnecting one electrical attachment, a gas line, the controls, and a few easily accessible bolts. (Manufacturers please note that the oil tank and system is part of the power plant.) The entire aircraft structure and furnishings should be an assembly of units which can be quickly and easily disassembled and reassembled.

When designing the installation of the accessory and instrument systems, care should be taken to group associated items in readily accessible and quickly removable compartments or panels. Any items which cannot be congregated in such a manner should be individually disposed in such a way that they can be reached and replaced in a maximum period of five minutes.

None of these construction features are in any way impossible. To some extent the airlines themselves achieve some measure of maintenance facility and interchangeability after delivery from the manufacturer. There is much, however, that cannot be corrected after construction and must be accomplished in the basic planning and development.

With aircraft designed and constructed in the manner I am suggesting, a picture very different from the present one would be seen in the function of maintenance and overhaul.

With the facility of quickly replacing a unit requiring reconditioning, the aircraft need only be grounded during the process of change; the reconditioning of the removed unit could be done at leisure after the aircraft has proceeded on its way. The interruption of flight schedule by mechanical defects would be reduced to a minimum. For example, if a spark plug goes dead (which generally necessitates up to a three-hour job to replace the set) the entire power plant would be quickly pulled out and the schedule continued with a replacement unit.

ADVANTAGES OF IMPROVED MAINTENANCE

Such a system would have many advantages which may be listed:

1 The improvement in regularity of schedule is obvious.

2 The hours in service per day per aircraft would be appreciably stepped up.

3 The overhaul or reconditioning of units could be planned in a smooth flow of work. The high-pressure rush periods and depressed slack periods would be largely eliminated.

4 The overhaul of aircraft would be going on continuously without the present large sacrifice of valuable revenue hours.

Since the earliest days of flying machines, several factors have contributed to develop flight operations as we see them today.

Briefly examining a few of the more important of these factors, we see that aircraft structures and engines are now very reliable jobs of engineering. Mechanical defects and irregularities no longer jeopardize the safety of operation and I have just outlined some proposals to overcome the defects in regularity.

Weather reporting and forecasting has progressed a long way since the day when before taking off, one tossed some blades of grass in the air to find out which way the wind was blowing. We cannot yet control the weather but weatherman services have become reasonably reliable and, with war restrictions removed, will undoubtedly be on the way to becoming an exact science.

One of the greatest contributions to successful flight operations has been the development of aircraft radio; continuous contact with aircraft in flight, precision in navigation by "beam" flying, position fixes or bearings are now commonplace, while static free radio, terrain clearance indicators, blind-landing systems, radio control, and radar are opening up new vistas.

Aircraft accessory and instrument development has greatly increased the scope of operations and when used correctly contribute greatly to safety and regularity.

PILOT THE MOST IMPORTANT FACTOR

In all the phases of operation, the advance has been rapid and reliable but there remains one and possibly the most important factor of all that has not, and cannot adequately progress with the present system. I refer, of course, to the pilot of the aircraft.

In earlier days a pilot was a mixture of a fool and a juggler. His instruments were very elementary and the seat of his pants was the most reliable guide he had to tell him if his juggling with joy stick and rudder bar was producing reasonably correct results. Don't misunderstand me, I take my hat off to these boys. They made air transportation possible. Since those early days there has been rapid advancement of the flying machine. The increased efficiency of airframes and engines has greatly extended the scope of operations; the development of radio and precision blind-flying instruments has made it possible to navigate accurately without visual contact with the ground. Blind-landing systems and precision altimeters now allow operation under hitherto impossible conditions of cloud height and ground visibility, but the fact is incontestable that the safety of air transportation rests on the pilot of the aircraft. We are completely reliant on that most unstable of all unknown factors—the individual human being.

Most people will argue that the addition of all the present-day specialized equipment and adding specialists to the flight crew decreases the load on the pilot. I contend this is totally wrong. A study of the facts quickly shows and is proved by the record of accidents, that each new development, each new so-called aid or safety device, has placed a further burden on the skill and knowledge of the pilot and has been used to permit operation under still more adverse atmospheric conditions than was previously possible.

In no other form of transportation are such terrific demands made on a human being. Additional training, additional "aids" cannot correct this condition.

Now I will examine aircraft flight ope ation as I believe it can and must be, before we can hope to make any real progress.

First, I'd like to take an example from one of the older brothers in transportation.

If my understanding is correct, the "underground" or "tube" train system used in London, England, which handles astronomical numbers of passengers each day is completely provided with automatic safety controls. There is a driver or engineer aboard all trains, but apart from stopping and starting at the exact spot on the station platforms, and maintaining his stop-to-stop schedule, there is nothing he can do which will jeopardize the safety of his passengers. If he fails to stop at a station, the train is stopped by automatic control. If he gets ahead of schedule to the point of overtaking a train on the same track, the power is automatically cut off. It is impossible for a delayed train to proceed on its own initiative unless all tracks ahead of it are clear. If the driver falls asleep or

otherwise becomes unconscious, the power is disconnected from his train by a "dead-man control."

This whole system is controlled by comparatively elementary electrical devices, yet the result to date is 100 per cent safety of operation. Some inconvenience to passengers perhaps on occasion, but never an injury, never a serious dislocation.

Every element that could endanger the safety of passengers in this extensive system has been designed to eliminate reliance on the individual human element.

The same basic principles as used by this British railway system, adopted and developed for flight operation, presents a most logical future for air transportation.

In my conception of correct flight operations, the mechanical handling of aircraft will be completely and automatically controlled from ground stations.

Consider for a moment some of the radio and instrument developments that presently exist: (1) Since the early 1930's, the DeHavilland *Queen Bee* has been used as a radio-controlled antiaircraft gun target; (2) the Lorenz and Indianapolis blind-landing systems have been used for some years; (3) the control of flight path by an automatic pilot has almost reached perfection; (4) with provision of correct ground facilities, we have aircraft position indicators which will exactly locate an aircraft over any route in the world. Radio beams, collision indicators, terrain clearance indicators, Radar, and hosts of other developments are presently available. It takes but little imagination to visualize an integrated system of ground control built with this existing knowledge.

I am not suggesting for a minute that aircraft will be controlled from the ground in the immediate postwar period, but I am suggesting that now is the correct time to adopt the principle.

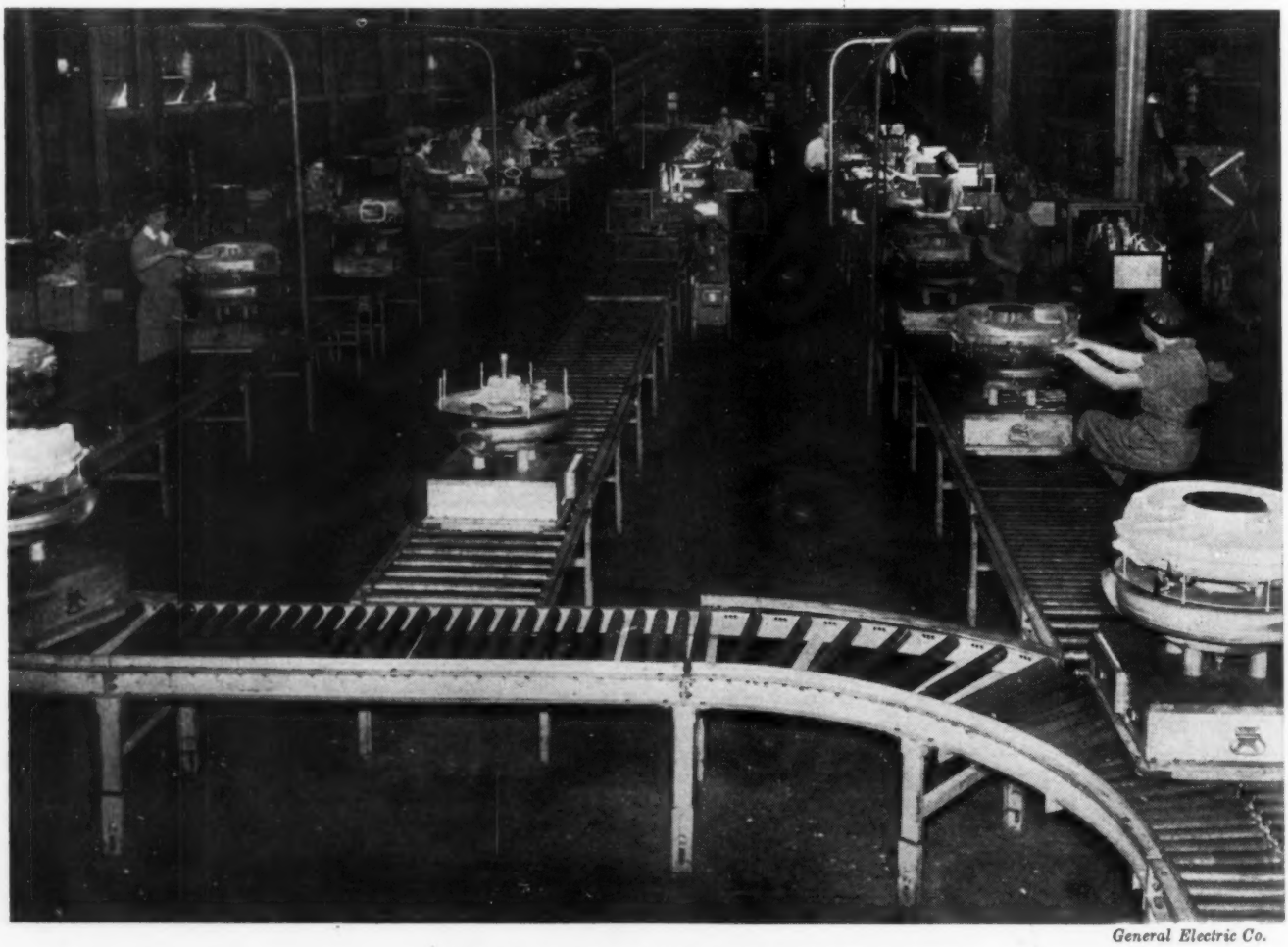
Imagine for a moment an aircraft in stormy weather, or met with unpredicted adverse weather conditions. With his mind free of the encumbrances of a host of mechanical gadgets, our future air-line captain will be able to apply all his mature judgments to governing the flight conditions. He won't be wrestling a control column and rudder bar because they, I hope, will be painted red and tucked away in a glass case labeled "for use in extreme emergency only."

SUMMARY

Before closing this discussion, I think it is correct to look a little further into the future. There appears to be three phases through which we must develop. The first I have described as I see it and can be covered by a repetition of my convictions that there will be no revolutionary changes in aircraft for some years in the postwar period, but we can expect a considerable change in the detailed design of aircraft and the principles of flight operation.

The second phase will develop naturally from the first and in it we will see revolutionary designs of greater efficiency.

The third phase will be reached only when some degree of stabilization of aircraft design has been attained. It will be in this third phase that we can expect great reductions in the cost of air travel and the universal acceptance of the flying machine as the standard method of transportation.



General Electric Co.

ASSEMBLY LINE FOR TURBOSUPERCHARGERS

The CONTINUING NEED *for the* CONSERVATION *of* RESOURCES

By HOWARD COONLEY

CHAIRMAN, CONSERVATION DIVISION, WAR PRODUCTION BOARD, WASHINGTON, D. C.
CHAIRMAN OF THE BOARD, WALWORTH COMPANY, NEW YORK, N. Y. ASSOC. A.S.M.E.

MATERIALS, facilities, transportation, and manpower are basic to success in war as they are essential to progress in time of peace. Where such resources are not available, experience and ingenuity must be called into play to provide them. Once more the world is witnessing a demonstration that free men, given the opportunity to develop their latent abilities in the democratic atmospheres of the Allied Nations, can outproduce and outfight the peoples of the regimented and therefore restricted nations.

Even in countries so rich in material resources as the United States and Canada, such huge quantities of materials, facilities, and transportation as a war of world-wide proportions requires, do not lie ready for our immediate use. The exigencies of war compel us to plan, design, construct, convert. We must make two blades of grass sprout where one grew before. We must stretch. We must conserve.

Soon after the Office of Production Management was established, on Jan. 7, 1941, it became apparent that it would be necessary to discover ways and means of conserving the material resources of the United States if we were to become in truth the Arsenal of Democracy.

With this purpose in mind, C. Laurence Warwick, secretary-treasurer of the American Society for Testing Materials, was called to Washington in April, 1941, by Donald Nelson to take over the responsibilities of reviewing specifications. In August of the same year Harvey A. Anderson obtained leave of absence from the Western Electric Company to develop for the Government a program of substitution out of critical materials into those that were more abundant. Six months later Dr. Edwin W. Ely, of the National Bureau of Standards, joined the Office of Production Management to add his background of experience in the field of simplification.

It was not until January, 1942, that the War Production Board was established to take over the duties of the Office of Production Management, as well as those of other agencies concerned with production and procurement. A few weeks later, the Bureau of Industrial Conservation, which had been formed in September, 1941, under the directorship of Lessing J. Rosenwald, was set up within the structure of the War Production Board as the Conservation Division, to co-ordinate the related functions of substitution, specifications, simplification, and standardization. At that time the primary responsibility of the Conservation Division was that of securing adequate supplies of raw materials.

The impact of the disaster of Pearl Harbor highlighted the importance of conservation. It was immediately recognized that our responsibilities for conservation extended beyond the realm of materials into those of facilities. Still later, the scene again changed to include transportation and manpower. Today manpower is number one on our critical list.

The Conservation Division of the War Production Board is a staff agency. Its responsibilities are exclusively advisory. It is in effect a general engineering and technical staff for the War Production Board.

Presented at a joint meeting, Toronto, Canada, Sept. 30–Oct. 2, 1943, of The Engineering Institute of Canada and The American Society of Mechanical Engineers.

Our consultants have been recruited from the research and engineering laboratories of industry and from scientific institutions and associations. I believe I can say, with due modesty, that the caliber of our staff is outstanding, the quality of our advice such as to carry conviction. To illustrate, of our 71 consultants, 6 are chemists, 31 are engineers, 11 are metallurgists, 5 are technicians, and 7 are architects. The staff averages 23 years of experience in industry. These 71 consultants are trained in the techniques of substitutions, specifications, simplification, and standardization and apply these techniques to produce the greatest possible conservation of our resources.

The Conservation Division also has representatives on four of the most important committees of the War Production Board: the Program Adjustment Committee, Clearance Committee, Appeals Board, and the Facilities Committee. Through the Conservation Division's representation on these committees we have the opportunity of bringing to their deliberations the cross-section viewpoint of all of our industry divisions, as well as that of other government agencies. For through the medium of our interagency staff we have daily liaison relationships with the Army, Navy, Lend-Lease, Treasury Procurement, and Office of Economic Warfare, as well as with Canada and Great Britain.

I have given you this background because I feel it will be helpful in measuring the effectiveness of the Conservation Division in its specialized techniques.

SUBSTITUTION

In the early stages of our conservation program substitution was used as a means of relieving excessively heavy demands on certain materials that were insufficient in quantity to take care of our rapidly expanding production program. With the loss of the Malay Peninsula and the Dutch East Indies, vast reservoirs of precious materials were cut off almost overnight, making it necessary for us to find new sources of supply or to discover ways and means of using available materials to replace those that were no longer obtainable.

Three general methods were used in achieving substitution. The first is a complete change of material. For example, when our aircraft program made aluminum a very critical material, we experimented with substitutes for it in such products as canteens and were able to develop a satisfactory stainless-steel canteen that has been accepted by both the Army and Navy.

In other cases, where a complete change of material was not possible, we were able to accomplish our purpose by using less of the critical material in question. An example of this type of substitution would be found in galley equipment and mess equipment where we were able to substitute stainless clad steel in place of solid stainless steel, thereby saving better than 90 per cent of the stainless steel involved.

The third type of substitution consists of downgrading the same material for a given product. An example of this may be found in propeller-shaft sleeves for Maritime ships, wherein we have been able to substitute "M" metal, a composition of 88 per cent copper, 6 per cent tin, $4\frac{1}{2}$ per cent zinc, and $1\frac{1}{2}$ per cent lead, in place of "G" metal, a composition of 88 per cent copper, 10 per cent tin, 2 per cent zinc, and no lead.

Virgin copper has from the first been one of our critically short materials.

The Silver Program. The proposal to use silver as a substitute for copper in bus bars was first suggested by Dr. Zay Jefferies of the Research Council, Sept. 26, 1941. On Oct. 6, 1941, the Conservation Division recommended this use of silver to Donald Nelson, and in February, 1942, negotiations started with the Aluminum Company of America at Pittsburgh to use silver bus bars in 20 "pot" lines for the manufacture of aluminum. After many legal obstacles were overcome, a contract between the Defense Plant Corporation and the Treasury was signed on May 6, 1942, providing for a loan of 34,286 short tons of silver to the Defense Plant Corporation, who would make all arrangements for guarding, transporting, casting, and fabricating the bus bars. Most of the silver bus bars are being used in the new aluminum and magnesium plants and to date we have certified about 20,000 tons of silver bus bars which have saved 16,000 tons of copper.

Nickel Program. In its eager search for every possible means of reducing the demand on highly critical metals the Conservation Division found that some 3600 tons of copper and 860 tons of nickel were being used annually in the fabrication of 5-cent pieces, generally known as nickels. With the assistance of George Hogaboom and Dr. A. K. Graham, two of our consultants, we furnished the Treasury Department with a revised specification on nickels using an alloy of 56 per cent copper, 35 per cent silver, and 9 per cent manganese, instead of 75 per cent copper and 25 per cent nickel in the original coin, thereby entirely eliminating the use of nickel. This composition had nearly the same specific gravity, magnetic, electric, and elastic characteristics possessed by the original coin and therefore was usable in telephones, vending machines, and automatic coin machines of all types.

The Steel-Cartridge-Case Program. In cartridge cases, as in many other products, it was the obviously extreme shortage of copper that made it apparent early in 1942 that some substitution would have to be made in order to give the Army and Navy their requirements in ammunition. Steel cartridge cases had been the subject of experiments for years and had been used by the Germans and Russians, but their guns had been designed to take steel cartridge cases while ours had been designed for brass, and therefore our problem was more complicated and more serious than either that of the Germans or Russians. In May, 1942, the Conservation Division was asked to assist in the problem of developing satisfactory steel cartridge cases, and investigation and research was undertaken by Dr. A. B. Kinzel, one of our steel consultants. After many obstacles were overcome in the fabrication of a satisfactory steel case, the 0.45-caliber-size ammunition was completely converted from brass to steel, with a production of over 300 million per month. At present the 0.30 and 0.50-caliber sizes are also in production at a slightly lower rate, and we have been successful in furnishing the 105-mm case, the 20-mm case, the 40-mm case, and even as large as the long 3-in. gun case (Navy), all of which have been certified for combat use and are now in full production.. At the present rate we are showing a savings in brass of approximately 200,000 tons a year, and this figure is rising rapidly. The conversion has been so effective that further conversion from brass lines to steel is temporarily suspended pending the forthcoming 1944 requirements for ammunition.

The Die-Casting Program. The use of die castings as a conservation measure has been a part of the Conservation Division's program for more than two and a half years. Through the efforts of our consultants hundreds of items have been changed from screw-machine products, forgings, sand castings, and other methods of fabrication to the die-casting process. The expanded use of die castings with their characteristic high-speed production and low scrap loss has represented huge savings in critical materials, manpower, and machine-hours.

We have worked with the die-casting industry through industry advisory committees, co-operating with them on many problems of production, inspection, and process control. Through the establishment of proper control and inspection procedures, it is expected that the die-casting process can replace satisfactorily many critical parts now produced as forgings or wrought products, thereby saving much metal and many machine operations.

SPECIFICATIONS

Specifications provide an important means for conservation. A purchase specification is simply a detailed statement of the requirements that must be met by the product under consideration.

The United States Government is undoubtedly the largest buyer that the world has ever known, and it is all-important that the quality and performance of all products purchased be a fair exchange for the money paid for them.

The system of federal specifications was established to standardize the grades and sizes of products purchased by more than one government department. They are prepared by 71 federal specification committees composed of representatives of the various government departments interested in the product in question.

When a product is used by only one department, that department prepares its own specification. For instance, there are many Navy Department specifications for products used only by the Navy. Similarly, the War Department prepares certain specifications for it own use.

The Conservation Division is represented on all federal specification committees and takes part in the preparation of the specifications to see that true conservation of the scarce materials is practiced. We also review specifications prepared by the Army, Navy, and other government departments to see where conservation can be effected. Two methods of conservation are considered in this review:

1 By issuing amendments limited to the war period specifying substitutes in place of critical materials needed in the war program.

2 By issuing emergency alternate federal specifications to indicate alternate materials for consideration.

In the design of modern equipment, advantage was taken of the superior properties provided by modern materials of construction, such as aluminum, copper, brass, alloy steels, rubber, and plastics, to provide greater durability and greater convenience, and in many cases, lower cost. With these materials so urgently needed for the war program, it has been necessary to replace them by others, which, while not quite as satisfactory, will still do the job. Many government specifications, therefore, have been reviewed and changed to specify available materials in place of those that are short.

For instance, specifications for bronze valves were changed to call for cast iron, sometimes with bronze seats.

Specifications for large searchlights were changed from aluminum castings to sheet steel.

Specifications for fire-hose couplings were changed from high-tin bronze to malleable iron for shore use, and low-grade bronze for shipboard use.

Specifications for wire-screen cloth were changed from commercial bronze to galvanized steel wire.

The federal specification covering tissue paper, a special Japanese tissue no longer available, was revised to describe a new type of American tissue.

Specifications for a number of rubber products have been issued as emergency alternate federal specifications to allow the use of reclaimed rubber.

Another step in conservation was realized through the establishment of National Emergency Steel Specifications. This work has the objective of standardizing and simplifying specification requirements for steel-mill products, simplifying

dimensional requirements, and conserving critical ferroalloys by adjustments in composition. It is in the hands of technically qualified representatives of producers and consumers. J. G. Morrow of the Office of the Canadian Steel Controller has actively participated in the work.

Fifteen schedules under W.P.B. Limitation Order L-211 have been issued to control the production and delivery of their respective products.

About 65 per cent of the steel-mill production is now covered by order schedules or agreements.

These schedules in general list two kinds of permissible specifications: (1) selected government specifications for government use only, and (2) specifications for general use, either by government or private industry. In this latter category, selection of specifications is made from those issued by recognized national organizations, so that all private consumer specifications not in agreement with a listed specification are ruled out. This simplification of the specification field has been a very important contribution to increased production with existing facilities.

Schedule 15 to order L-211, covering hot-rolled carbon-steel bars, was issued after a tremendous amount of research by the carbon-steel-bar industry and the Technical Advisory Committee on Carbon and Alloy Steel Bars. This schedule eliminated 40 per cent of the carbon-steel-bar sizes, or 5 per cent of the total tonnage.

Reports from the industry indicate an increase of 5 per cent to 15 per cent in the effective use of production facilities, accomplished through longer runs, less roll changes, smaller inventories, and less rejections.

SIMPLIFICATION AND STANDARDIZATION

Simplification as we conceive it may be defined as the elimination of those items, types, sizes, and colors of products which do not serve the war effort; in fact, many of which do not serve any economical purpose. In most instances they are a positive hindrance to the flow of essential products to the armed services and to civilians.

To make simplification effective, a certain amount of standardization is usually necessary. But standardization, as interpreted by the Conservation Division of the War Production Board, is not the molding of styles and types of products into a fixed form. It is not a requirement that identical procedures or designs be followed which would destroy individuality.

Often it is only a single element in a product that must be standardized in order to achieve the necessary degree of simplification. Very seldom is the standardization of more than a few elements necessary.

Standardization as to quality is sometimes necessary in order that the buying public be protected in their purchases. The purpose of standards of quality or of performance is to assure the public of their getting their money's worth. It acts as a brake against the wasteful use of critical materials and facilities in the production of goods that will not serve the purpose for which they are intended or that will deteriorate rapidly. It is an insurance policy to the honorable producer against those who are less honorable.

Another important role played by standards is to provide for interchangeability, particularly in combat equipment. A large part of such equipment is being shipped to far distant lands. This equipment must be repaired quickly and on the field of battle. It is self-evident that the interchangeability of components of tanks, trucks, and jeeps will reduce the necessity for creating large floating stocks of repair parts. Much progress has already been made in the field of interchangeability. More is in prospect.

Methods. Recommendations regarding products that may be simplified or standardized come to the War Production Board in many different ways. A majority of the suggestions come from industry directly, through trade associations, or through the W.P.B. industry advisory committees. Others are received from the War and Navy Departments, the Office of Price Administration, and other agencies concerned with either procurement or regulatory actions.

The problem is normally referred to the industry division responsible for the product or material involved, with the Conservation Division consultant acting in an advisory capacity as a staff function. A rough check is made to determine the value of the recommendation from the standpoint of helping to win the war. If the saving in materials, manpower, or facilities will justify the action required, a detailed study and recommendation is made by one of the following:

1 The industry division.
2 A task committee of the industry advisory committee.
3 National Bureau of Standards or other government agency.
4 An independent technical association.

The simplification or standardization program is then presented to the W.P.B. industry advisory committee for comment. Necessary changes may be referred back to the responsible committee. The final program is then incorporated in the draft of a limitation order which is circulated to the Army-Navy Munitions Board and to all divisions of the War Production Board that would be affected by the action. Following suitable settlement of all objections, the order is issued and the program is thereby made effective.

Examples of simplification and standardization programs that have been developed are given in what follows.

EXAMPLES OF SIMPLIFICATION

1 *Simplification in pipe fittings* made of cast iron, malleable iron, or brass reduced types and sizes by 65 per cent and still fulfills 94 per cent of total demand and increased possible output by 25 per cent.

2 *Simplification of universal portable electrical tools* reduced sizes and models by 25 per cent, reduced the number of types of drills from 338 to 200, and increased productive capacity 10 per cent.

3 *Simplification of incandescent and fluorescent lamps* reduced types from 3500 to 1700, colors from 13 to 3, and voltages from 32 to 7. This schedule saves 35,000 lb of solder, 2000 lb of tungsten, and releases 1,200,000 man-hours per year.

4 *Simplification of types of men's work clothes* reduced the number of types of garments to 6 and makes savings in excess of 21,000,000 yards of cloth; sufficient for 7,000,000 new garments over a period of one year.

EXAMPLES OF STANDARDIZATION

1 *Standardization of air-cooled gas engines* was effected by reducing the number of basic models by 50 per cent, thus reducing the number of repair parts by 40 per cent. Each manufacturer standardized his models so as to use the same type and sizes of various parts in as many classes of engines as was possible. This is an example of company standardization.

2 *Standardization of electrical indicating instruments* makes possible interchangeability in combat vehicles, through reduction in variety of sizes, from more than 90,000 to 2100 sizes. Production is thereby substantially increased.

3 *Standardization of radio parts* reduces the variety from an innumerable number of parts to 42 and insures a reasonable production for civilian supply.

CO-ORDINATING COMMITTEES

One of the most effective means we have had of promoting conservation has been through the medium of co-ordinating committees. In September, 1942, an interagency Conservation Co-ordinating Committee was set up under the chairmanship of the Director of the Conservation Division. The committee was composed of the heads of the conservation activities of the

Army, Navy, and Maritime Commission, and the chiefs of the three branches of the Conservation Division.

Later this committee was expanded to include representatives of the Office of Lend-Lease Administration, Treasury Procurement, Board of Economic Warfare, Aircraft Production Board, Great Britain, and Canada. Biweekly meetings have been held continuously, at which over-all conservation programs have been discussed. Where a consensus of approval was indicated, the individual representatives have promoted the programs within their own organizations and in this way made them particularly effective.

The fact that the Conservation Division has had for over a year representatives in London, attached to the Harriman Mission, has brought about a continuous flow of information between the two allied countries which has been still further implemented by the able assistance of H. K. Wilby, who is representative of conservation for Canada assigned to the Conservation Division, and F. A. M. Tabor, similarly representing Great Britain.

Within the past few weeks this close relationship and interchange has been expanded and formalized by the creation of the Combined Conservation Committee, under the sponsorship of the Combined Production and Resources Board and the Combined Raw Materials Board of the United States and the United Kingdom. The effectiveness of this method of interchange of information has already been demonstrated.

EDUCATIONAL PROGRAM

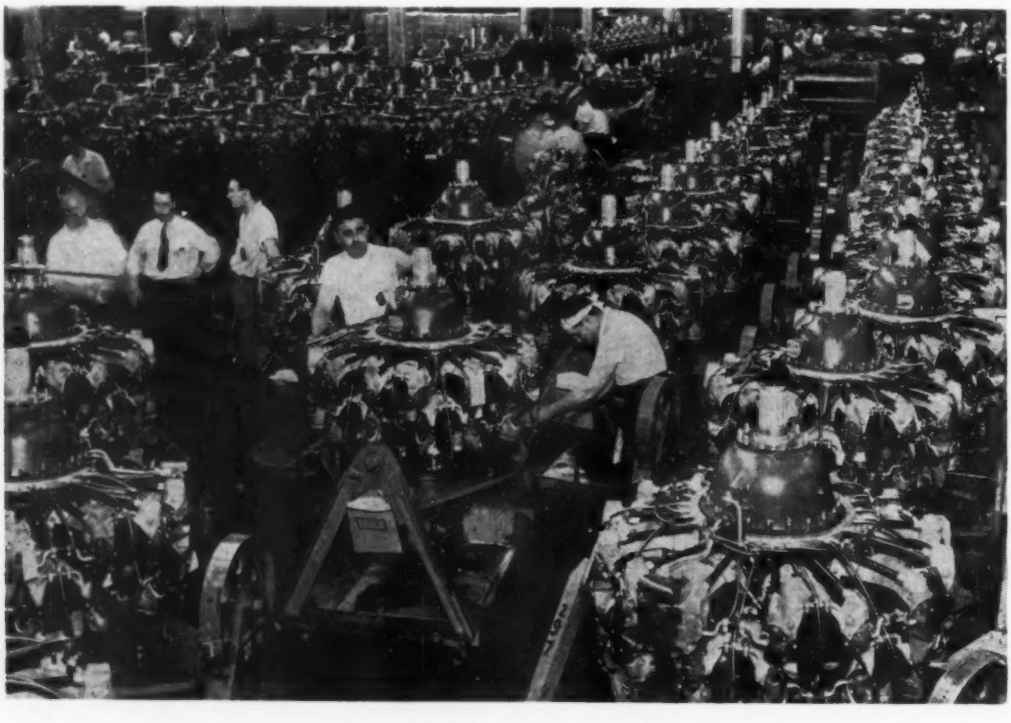
One of the most effective means of achieving conservation is an appeal to the patriotism and good sense of the individual through the radio and press, indicating definite ways and means by which savings can be accomplished. This method is being given increasing emphasis in the last few months, expedited by the unselfish co-operation by industrial, commercial, and engineering groups.

One such campaign, to conserve cutting tools, is now drawing to a close. This was planned and developed by the Conservation Division with the co-operation of the War Advertising Council. The campaign book, posters, and stickers that carry the slogan, "Tools Are Weapons—Treat 'em Right," were distributed largely through the 2500 members of the National Industrial Advertisers Association, aided by the National Association of Manufacturers. We also had effective co-operation from 2200 labor management committees through the War Production Drive and 825 mill-supply houses. Through all these sources, plus the efforts of Mr. Wilby, the campaign has been brought to Canada also. Altogether this campaign is having a splendid reception.

Another current campaign, just getting under way, is on cordage. Manila fiber was entirely cut off when we lost the Philippines. The Rope Conservation Committee of the Cordage Institute is handling the campaign in co-operation with the War Advertising Council, under the direction of the Conservation Division. Though the chairman, Edwin G. Roos of Plymouth, Mass., was appointed only on August 14, already he has raised funds from industry, prepared, had approved by Washington, and published all the material for an unusually excellent and complete campaign which is gaining rapid headway. We like to think that this cordage campaign will serve as a pattern for similar future activities, blending the efforts of the Conservation Division and industry to assure rapid effective action on vital conservation needs.

I have already indicated the changing complexion of our conservation problems. Recently we have reviewed the responsibilities of our division and developed a revised policy to meet these changed conditions. As certain materials become adequate, our program, to some extent, must be put into reverse gear. Yet we conceive it as our duty to safeguard and guide the relaxation of controls as carefully as they were designed. In other words, we must recommend that surplus resources as they develop shall be channeled into those products which will assure the greatest benefits to the war effort.

And so conservation must be carried on until every Axis nation is subdued and the world can be assured of a lasting peace. And after peace there will be the problem of reconstruction for the war-torn countries, which will require conservation for their solution. And after peace and reconstruction there will remain the age-old problem of enough to feed, to clothe, and to shelter all mankind. CONSERVATION IS ETERNAL.



MASS PRODUCTION OF CONSOLIDATED B-24 LIBERATOR BOMBER ENGINES IN BUICK PLANT

THE ENGINEER AS PLANNER

By RALPH E. FLANDERS

PAST-PRESIDENT, A.S.M.E.; CHAIRMAN, COMMITTEE ON RESEARCH OF COMMITTEE FOR ECONOMIC DEVELOPMENT; PRESIDENT, JONES AND LAMSON MACHINE COMPANY, SPRINGFIELD, VT.

SOME ten years or so ago it chanced that I appeared at a round-table discussion at which another participant was one of the leading economists of the country. Before the meeting, we were being entertained at dinner, and in the conversation around the board, my economist friend remarked that the worst thing that could happen to the country was to put its economy in the hands of engineers.

This seemed at the moment like an uncalled-for criticism of the abilities and usefulness of our profession and, as can be imagined, I was up in arms at once.

When, however, he began to expand his point of view, it began to appear as true and important. It may serve a good purpose to review that point of view even today, after the lapse of a decade of turbulent history.

It would be disastrous to apply engineering procedures directly to the control of society. It would be disastrous because it is completely unworkable to treat human beings, whether individually or in the mass, as though they were machines subject to simple, invariable, mechanical laws which can be discovered, organized, and successfully applied. However much we may discover about the causes and the nature of human actions, the control of them still remains an art rather than a science, and it certainly will remain an art rather than a science so long as any of us who are here present live and have the faculties intelligently to observe.

How many of us remember "Technocracy?" It was the spectacular economic fallacy of that day. It was the attempt of a poorly informed intellectually confused engineer to reduce social problems to engineering terms. It struck terror into the hearts of some groups and aroused unwarranted hopes in the hearts of others. More seriously, the possibilities of the direct use of engineering principles in our current problems fascinated some engineers of real ability. This was the serious and the dangerous thing.

How dangerous it was we can see clearly in retrospect when we review the history of Germany in the period between the two wars. In that nation, every resource of science, every resource of engineering was bent toward the development and carrying out of a social end. That end was the building up of Germany into an irresistible world power. Pure science for its own sake disappeared. Engineering as applied to its normal, limited objective of undertakings useful to human progress was caught in the net of national control and made abjectly subservient to the nation's paranoiac objective.

Not merely was science and engineering thus enslaved, but cultural studies and the humanities as a whole were in large part abolished, while the remainder was likewise channeled into the service of the national objective. The great search for truth was abandoned. German scholarship and professional integrity were alike prostituted to an unworthy purpose.

In a great address made a year ago in New York, Dr. Hopkins, president of Dartmouth, described this situation and made an eloquent plea for the preservation of the humanities and for their independent cultivation outside of the control of government or of organized majorities. He performed thereby a great service in putting his finger on one of the greatest dangers with which we are faced—that of the political supremacy of technicians in a centralized government. It should be a matter of great concern to us in the engineering profession that we resist the fatal fascination which we are all liable to feel for the direct application of engineering principles to social problems. The danger having thus been pointed out, let us proceed to consider just where our contribution lies and just how we can best make it.

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We are faced with the necessity for a considerable measure of planning. This necessity will be made still more clear by the difficulty of shifting our operations from the first total war in which we have ever been engaged over to a peacetime economy in which, again for the first time, we meet the opportunity of a high level of employment, production, and human satisfaction.

The problem divides itself into two parts. The first is the determination of what is economically, industrially, and scientifically possible. The second is the question of what is politically possible.

We must never forget that this second question—what is politically possible—is the ruling factor. Ultimately, politics in the broad sense determines what we can do and what is going to happen to us. Your speaker does not have the wisdom or experience to make authoritative pronouncements on this score. All of us, as citizens, are a part of the influences which make reasonable procedures possible or impossible. As specialists in our profession, we have simply to realize that our usefulness is limited by the political conditions in which we participate as citizens. Let us turn at once, therefore, to some reflections on that area of our problem which is more nearly a science than it is an art.

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The subject of economics occupies the middle ground between the two. It is classified as a social science. That classification in itself indicates its position midway. None of the social sciences is so clear in its relations of cause and effect, or has such clearly definable causes, that effects and results can confidently bep redicted in advance. Economics itself is a study of human behavior. It is based first and earliest on generalizations derived from observation, more lately and more specifically on statistical studies of human behavior under conditions in which the causes were isolated, so far as isolation is possible.

Laboratory procedure is impossible. Experimentation by varying one factor at a time and observing its influence unaffected by other factors is unattainable. The laboratory is the nation as a whole and the world as a whole. The variables are numerous and complex, and they do vary beyond our control.

If this is a mechanism, its nearest approach in physical terms is to celestial mechanisms, in which there are no fixed points and only kinetic constraints on the movement of the elements. The disturbance of the movement of the smallest and most remote body affects the movement of every part.

We have discovered the complex nature of these relationships first in our endeavors in the United States to control recovery and secondly in the necessary attempt to control and direct our economy to the waging of an all-out war. Every time some apparently simple and obvious action has been adopted—for instance, in price or production control—its effects have spread throughout the whole structure and have resulted in disturbances which were unexpected, difficult of correction, and sometimes almost disastrous.

A current example is the difficulties which have been developed by the prices which have been set on such simple earthy products as corn and hogs. The price of corn has been

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so set that it is more profitable to feed it to hogs than, for instance, to dairy cattle and poultry. In consequence, it has been so fed on an enormous scale. Also, incidentally, the selling prices on hogs have still been such that, in connection with frozen prices on pork products, all of the smaller meat-packing houses have been thrown out of production, leaving the industry in the hands of the big packing houses.

As a result, the States are threatened with a cutting down of the dairy industry and a shortage in our milk supply, at a time when the requirements for fluid milk domestically and for powdered milk and cheese for export are of extreme importance. Poultry products, particularly powdered egg, again essential to our allies in the conduct of the war, are likewise destined to be curtailed. The complexity of disturbances reaches into transportation, into the cost-of-living index and wages, and unfavorably affects the whole task of restraining the inflation spiral with its destructive effect on savings and our future well-being.

The most hopeful thing that has come out of our wartime administration was the remark made by a man in high place in our war administration a few months ago, to the effect that he never realized what useful things the profit motive and the price system were until he had been charged with the responsibility for controlling our economy by direct action.

Society is not a mechanism. It is an organism. Let us never forget this. But where, in this case, shall we find the sphere for social action of the engineer?

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In the first place, the whole situation demands the engineering approach. It is the role of the engineer to apply the discoveries of pure science to the practical attainment of human desires. He stands and works with one foot in each of these two worlds.

Our society has long needed this point of view and this approach. We have had the scientists working as scientists in the expansion of human knowledge. We have long had human problems crying for solution. We are now engaged in the task of building up a technique of social engineering which shall bridge that gap in the social field as the engineer has bridged it in the physical field.

A moment ago, I spoke of society as an organism rather than as a mechanism. Perhaps this gives the clue to the procedure. Our most useful parallel may be between the social organism and the human organism, rather than between the social organism and the machine.

The endeavor to maintain the health of the human body has gone through a number of phases. Its first phase was the prescientific, in which untenable physiological theories such as that of bodily "humors" in the theoretical field and the deadliness of "night air" in the popular field held sway. Animistic remedies and safeguards of fetishism were invoked.

Then scientists began to learn something about the human body and, at the same time, began to note the effect of various drugs, and we had a period in which symptoms and medication were, I suppose, the foundation of medical science. A large measure of usefulness still remains in this type of applied knowledge. Later, developments came in surgery, and for a time it seemed to the layman that the remedy offered for an unusually large percentage of human ills was to "cut it out." The specialist in cutting out this or that organ was in high repute—and he still remains so when his specialty is considered against the whole background of knowledge of human health.

The real triumph, however, in prolonging the healthful life of the race has been based on the science of hygiene. Better living conditions so far as they concern fresh air, exercise, and well-balanced diet have worked wonders. The whole study of vitamins and their natural or artificial provision in the human diet has worked wonders. The elimination of disease germs by proper sewerage disposal, food handling and refrigeration, and all the other improvements have added their quota to the sum total of human health and happiness.

As we look over the actual processes by which these undeniable and statistically measurable results have been reached, I am sure we will be convinced that, in a very large measure, the job itself has been done by engineers, while the specific jobs were set by the specialists in medicine and hygiene.

It will be useful to remember that the scientific study of the human body during all this period has not been in the direction of making its actions more simply comprehensible. Every new bit of knowledge has added immeasurably to the mystery of its complication and the mystery of its elaborate and microscopically confined chemical activity. The more complicated, the more incomprehensible we have found the human body to be, the greater success we have attained in ministering to its health and well-being.

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May I refer briefly to one endeavor being made at the present time to determine and apply effective principles of hygiene to the support of the health of our social body.

Many of you have heard of the Committee for Economic Development. It is an undertaking on the part of businessmen, first to assure that they play their part as businessmen in the postwar world, to make their contribution in their individual companies, in their communities, and in their industries to the maintenance of a high level of profitable productive employment. They can see that if this is not done, the body of our society, for inescapable political reasons, will suffer a very severe sickness indeed, so great that the well-being of every citizen will be damaged or destroyed.

In this detailed planning for individual companies, for communities, and for whole industries, the engineers concerned have a large part to play. They are concerned with the development of new products. They are concerned with the development of their communities and the public works which are needed therein and which can furnish a reservoir of employment for times when employment is falling off. They are concerned with the broader appraisal of the future of the industries with which they are connected—whether or not new products and new methods are tending to render them obsolete or whether new opportunities are arising out of new scientific developments which should lead to expansion and redirection.

The second part of "C.E.D.," as it is familiarly known, deals with these questions of social hygiene which have just been mentioned. This has been defined as the "climate" in which business lives and performs its functions. This climate may become unfavorable so that business cannot perform its social functions; it may become deadly so that those functions are practically impossible and chaos and anarchy result. We are committed to the belief that effective action lies in over-all controls rather than in the multitude of complicated and impossible specific controls that have seemed so necessary in total warfare, and which the O.P.A. official previously mentioned found so difficult of satisfactory application.

Your speaker is chairman of the Research Committee of C.E.D., which has set itself the task of developing the hygienic principles which, if applied to our society, will enable business to perform its socially useful function. It performs the engineering office of making application of the studies undertaken by a staff of technical men and an advisory body of social scientists, to the practical problems which it has posed. This is the true engineering function applied to social problems. In my belief, it is the most hopeful project now under way in the United States for reaching a practical solution of the immensely complicated problem which will face us as the war draws to a close.

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Our earnest attention to this group of problems is more than a domestic necessity for the United States, or for Canada, or for

any other nation. With the close of the war, we will be faced with an international crisis which the social conditions of the individual countries will affect and by which they will be affected.

It is becoming, I believe, increasingly clear that the determining factor in the postwar world lies with the relations between the United States and Great Britain on the one hand and Russia on the other, with a corresponding effect on the future of China. It is not necessary to go into a detailed discussion of this matter here, except to say that it overrides and overwhelms all planning of ideal world states, international police forces, world banks, and all of the other paper organizations on which we are so busily engaged.

We probably need not fear Russia from the standpoint of military conquest. We may confidently expect that after the terrific effort she has made in this war she will be concerned to an almost exclusive extent with the rebuilding of her industries and the reviving of her program for raising the standard of living among her own people. This is not the area in which she will pose her problem to the western world.

The problem she will pose will be a political one. We must not be surprised to find that she will come out of the war with her political influence dominant in the Baltic states, in Poland, and in the Danube basin. We must not be surprised if it is dominant in the Balkans. We must not be surprised if the only popular government which can be formed in Germany will be one which accepts Russian political opinions. It is even within the bounds of possibility that the same may be true of France and Italy. It is finally probable that the British Empire and the United States together will be unable to prevent this development.

To sum the matter up, we must raise questions as to whether we have any right, under the terms of the Atlantic Charter, to endeavor to prevent forcibly (and that would be the only way) this political development, each nation having the right to choose its own form of government. Not merely would we lack the right to interfere, but we would lack the right to question the wisdom of these countries in coming to such a conclusion, in view of the strength of protection which Russia has proved that she can offer and the weakness of the insurance on which the Western powers were able to make good when the need for cashing in on that insurance arrived.

This is the international postwar problem, and its repercussions will not terminate at the boundaries of those nations which tie up their fortunes with Russia. They will be felt throughout the body politic of the British Empire, as they are being felt today. They will be felt throughout the masses of our own citizens in the United States.

It can be demonstrated by historic analysis and by valid reasoning therefrom that these political principles from Eastern Europe never have and, in all human probability, never can and never will provide for the common man the advantages which free enterprise has provided for him in the past and which it can in larger measure provide in the future if the necessary over-all controls are determined and applied. These cold-blooded, logical approaches will not prevail. The only effective protection which the people of our western world will have against the spread of unfortunate ideology will be the active, rapid, and effective development of our own economy to higher levels of employment that are both profitable and productive to the mass of ordinary citizens.

This will be a real ideological war beginning as the physical warfare ends and increasing in intensity when the physical warfare ceases. It can never be anything other than tragic to have to throw a nation into physical warfare, but we can welcome this coming ideological contest with confidence and with joy. Our warfare will be waged by increasing the well-being of our country and its citizens, not by destroying that well-being. The peril is great; the opportunity is even greater, and engineers have a great part to play.

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PRODUCTION PACES THE WAR

By CHARLES E. WILSON

EXECUTIVE VICE-CHAIRMAN, WAR PRODUCTION BOARD, WASHINGTON, D. C. MEMBER A.S.M.E.

CHARLES E. WILSON

IN the fall of 1939 Hitler's Germany struck a new note in warfare. The planning and execution of military campaigns suddenly emerged as a gigantic contest in engineering skills. Back of the relentless panzer divisions and the screaming Stukas, there was marshaled and applied all of the technical knowledge and inventiveness of a highly ingenious industrialized people. *All* that Germany knew about machines and the use of machines was turned into deadly striking power. Warfare was reshaped in the light of modern techniques. War became so mechanized that no nation could hope to survive unless it could surpass its enemies in engineering skill and inventive ability.

Yet wars are still fought by men: *by* men, *with* machines. Today the men who fight must have enormous quantities of matériel. That matériel must be superior to that of the enemy. Our fighting men in this war can't do their job unless the engineer and the technician devise better matériel than the enemy has and find ways of making it in unlimited volume. The engineer is the strategist of the battle of production. His strategy has got to be good.

That puts it squarely up to you, as engineers.

In getting into a war of this kind, we may think we are on perfectly familiar ground. Our lives have been wrapped up in machines and their uses. In peacetime we strove for high quality and mass production, but the tempo was different. We went slowly from model to model. Improvements were carefully tried and tested before adoption. But in wartime, our product is tried in a test of fire. And as these tests reveal that changes are needed, those changes require immediate action. The whole process of production is thus affected. Work goes on at white heat. Constant improvement has to go hand-in-hand with volume production. The result is a never-ending problem of invention and production which the engineer and the technician must meet.

The pace of production in wartime is thus infinitely rapid. There is a corresponding stepup in the pace of technical advancement. And the blend of the two—steadily increasing volume and steadily improving quality—is the base upon which rests the military strategy of the whole war. In the long run our inventiveness and our ingenuity have got to exceed the inventiveness and ingenuity of our enemies.

That puts a terrific responsibility on us as engineers. The responsibility is primarily a demand on our skill and our technical ability, but it is also a demand for our understanding. We must realize what we are up against. We must know just what we are responsible for. Production paces the war, and the engineer paces production. The engineer has got to deliver.

Exactly what does that mean to us?

I think it compels us to begin by being very clear on three simple facts. These are:

1 The war has not been won. A good many men are going to die; billions of dollars worth of equipment is going to be destroyed before the armstice whistles start to blow.

2 Even if we were perfectly sure that the war had been won, we still would have no right to relax in our efforts to produce, because any let-down in production will surely mean unnecessary loss of life and the prolongation of the war.

3 There is a changing production pattern which we must follow, not merely to win the war, but also to insure the peace.

Let's examine these points briefly, one at a time.

THE WAR HAS NOT YET BEEN WON

There is, of course, a difference of opinion as to how long the war will last. By some criteria, we have a right to be highly optimistic. The United Nations are on the offensive, and the several offensives are meeting with splendid success. But before your optimism begins to run away with you, take a look at the maps. I don't mean today's encouraging maps alone, but rather today's maps in relation to the maps of Nov. 11, 1918. Some of our armchair strategists are saying that Germany today is about where she was in November, 1918, so that the end can't be far off. Well, that would be very nice if it were true—but the maps don't say so.

The maps say that we are far from having retaken all the ground or the material or the natural resources which have been seized by the enemy since 1939. The maps say that we have hardly done more than crack the surface of Hitler's *Festung Europa*. Our chance of breaking into that well-advertised fortress in the near future may be extremely good, but the maps say that we haven't done it yet. The maps don't tell us that we are entitled to a breathing spell; rather, they are a solemn warning that the hardest and costliest part of the job is still ahead of us. They show pretty clearly that Germany and Japan still hold, in territory and in resources, a great deal that belongs to someone else. They don't, in plain fact, look the least bit like the maps of November, 1918.

WE MUST NOT RELAX PRODUCTION EFFORT

Now, for the second point. Even if we insist on believing that our enemies are already beaten and will presently give up, we have no right to relax our production effort in the slightest

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degree. On the contrary, the very fact that victory was assured would make it more than ever imperative for us to continue increasing our production of war goods to the very limit of our ability.

The United Nations' war effort is complex. It is made up of many parts, and all of these parts have to fit together. Military strategy has to be co-ordinated with production schedules, with transportation timetables, with manpower assignments, and so on. Each of these subdivisions, in turn, is very complex, with many separate parts that have to dovetail. The failure of any part is not just a local default which can be shrugged off; it is a failure which affects and imperils the whole. It is a failure which must be felt on the battlefield.

You can remember the tragic cry, "Too little, and too late!" which we heard all too often early in the war. You remember what the results were. Soldiers who go to battle less well-equipped than their enemies fight under a terrible handicap, the price of which is paid in human lives. Let me repeat again—this is a war of engineering skills. There is a direct, provable relationship between an army's equipment and an army's casualties.

So every bit of equipment made today will save the lives of our fighting men tomorrow on some battle front. Any extra equipment, made through extra effort, will save extra lives. Why did the campaign in Sicily cost fewer lives than we had anticipated? Because the British and the Canadians and the Americans were able to be lavish in arming and equipping the invading forces. The engineering back of that campaign met the test—and a lot of our boys are alive today who otherwise would have died.

That is why we can't tolerate any let-down in production, no matter how good the news from the front may look. Are we nearer to victory? Then, for that very reason, increase the volume of production so that we save as many boys as possible.

THE CHANGING PATTERN OF PRODUCTION

Now, to the third point—the changing pattern of production.

Conditions governing the needs of our fighting forces are mobile and fluid. Nothing stays put in this war. Mechanized war is dynamic, not static. The very physical surroundings in which our boys fight change from season to season, and, as they change, corresponding changes must be made in the matériel our boys fight with. Day before yesterday we were fighting on the blistering sands of the desert; yesterday we were fighting on a rocky island; today we are fighting amid the mountains and the plains of southern Italy. Tomorrow, or the day after tomorrow, perhaps, our boys may be fighting in the green fields of northern Europe. And as the geography of our fighting changes, the problems of war production change accordingly.

For example: Now that we are no longer fighting in the African deserts there is a reduced demand for tank treads and air filters. The desert rocks and sands punished tanks, and there was a constant and imperative demand for replacement parts. The nature of that demand has changed: The changing geography of the war compelled the change. Yet as that change was made, the eternal requirement for new and better weapons brought about a different sort of demand, the demand, for instance, for the bazooka and its rocket projectiles, that man-from-Mars weapon that has proved so enormously effective against the enemy's armor.

These two very small examples of shifting demand could be multiplied a hundredfold. They prove very clearly that we need, not only volume production, but an exceedingly flexible and adaptable production system. In his recent message to Congress, President Roosevelt said:

> Even as the actual fighting engagements in which our troops take part increase in number, it is becoming more and more evident that this is essentially a great war of production. The best way to avoid heavy casualties is to provide our troops with the best equipment possible—and plenty of it.

That struggle to turn out the best equipment possible is unending. It makes our production job hard and costly. And it means virtually unlimited demands on the creative power of the engineer, the technician, the man with the know-how.

The best we can possibly do may be good enough today, but it will never be good enough tomorrow. We are not only in competition with our enemies: We are in competition with ourselves. We must always be beating our own records. New inventions and new techniques are carefully devised to give our fighting men that little margin of advantage that will mean victory. But these things never remain secret. Sooner or later the enemy always matches them, or even betters them. We reach one peak of technical or mechanical achievement only to go on to a higher one. We can never for one instant be satisfied with what we have done, no matter how good it is.

We have to follow that rule if we are going to win the war. But that isn't the end of it. The pattern set in this war is going to carry over into peace. That is inevitable. We have learned—at bitter cost—since this war began that no nation which tries to fight at half throttle can hope to survive. Aren't we also going to discover that it is fatal to live at half throttle in peacetime? If the peace that follows this war is to be secure, we will have to go on with the never-ending struggle to find and use the techniques that will enable us to make the best possible use of what we have.

DEVELOPING OUR POTENTIAL STRENGTH TO THE FULL

In 1939 or in 1940 it was obvious that the free peoples who inhabit the vast bloc of land running from the Gulf of Mexico to the top of the American continent—the peoples of the United States and Canada—had a greater potential strength than anyone else on earth. They had space, resources, machinery, men. They had the freedom to use these to the best advantage; they had the brains and inventiveness to tell them how to use them.

But this was merely potential strength. It had not been organized or mobilized so that it could be translated into actual power. It hadn't been turned into military power; it hadn't even been turned into full-strength peacetime power. The strength that enables a people to make the maximum possible use of what they have simply had not been put to work at full throttle.

To an extent the same thing was true of all of the United Nations. On paper, there simply was no comparison between the resources of the Axis and the resources of the nations which the Axis proposed to despoil. Those countries which have become the United Nations were incomparably superior. They had within themselves the resources which, if used properly, could have meant the direction of the affairs of the world. But the resources were latent. The free peoples of this earth had at their disposal the means to stamp down forever the Axis-born threat to their liberty and their security.

They could have insisted that this remain a world in which free men and women are free to work out their own destinies. But the power with which this could have been done was never marshaled. We did not make full use of the resources we had. In short, we had world leadership and we failed to exercise it.

So came the dark years of 1939, 1940, and 1941. The invasion of Poland, the Battle of France, the attack on Russia, Pearl Harbor—all of those grim milestones in human history represented attempts on the part of the Axis to strike the free peoples down before their latent strength could be turned into actual striking power.

Those blows failed. The margin by which they failed was painfully narrow, but they did fail. But as the blows fell, we grew both frightened and angry, and in our fear and anger we found inspiration.

You know what has happened since then. In Canada and in the United States there followed the most dynamic period of preparation for an all-out fight ever known in the history of the world. I would like to summarize the result in the words which President Roosevelt used to the Congress not long ago. He said:

> Our great production program started during the darkest days of 1940. With the magnificent contribution made by American industry and American labor, it is approaching full production. Britain has already attained full production. Today the British Empire and the United States together are turning out so much of every essential of war that we have definite superiority over Germany and Japan which is growing with every succeeding minute.

That brief statement is the account of an amazing achievement. Our countries today are measurably close to exercising, for the first time, the full potential power with which God has blessed us. They are beginning to find their own strength. The great gamble of our enemies has failed forever. The free peoples of this earth found themselves in time.

WARTIME LESSONS MUST BE USED IN PEACETIME

But let's not waste time patting ourselves on the back. As engineers, we can be proud of the way we met the test, but more tests are ahead of us. When this war is finally won, we have got to use in peace the lessons which we learned in war.

All of those lessons really mean the same thing, namely, that technical and mechanical obstacles need not keep a people from doing anything which that people really wants to do. We don't admit the impossible these days. If the impossible is something that vitally needs to be done, we find ways to do it. In this way we have broken through all kinds of physical limitations; to keep the peace secure, we must keep on doing the same. The challenge to our ingenuity, to our intelligence and alertness and determination, will be just as great in peace as in war. We shall have to go on being eternally dissatisfied with our own best achievements.

It took a world of ingenuity to adapt the great mass-production processes to the making of military goods. This war is not only completely mechanized; in its mechanisms it relies on workmanship and tolerances which would be exacting even if volume production were not called for. As engineers we had to take this host of involved finely tooled mechanisms and find ways of making them in unheard-of volume—the volume that can only be attained by mass production.

Yet that was only the beginning of the challenge. The demand for these weapons and implements was practically unlimited, and the time was short. Neither materials, manpower, nor factory capacity could be wasted. We had to begrudge every ton of material and every hour of time that was used. In a war in which money was no consideration, we nevertheless had to find ways of making these weapons more and more cheaply, for that is what saving manpower, machine time, and materials in a manufacturing process amounts to.

But while we made weapons faster and more cheaply, we also had to make them better. Our men go into battle; there they find that the enemy has some particular weapon which is better than their own. Immediately, therefore, we must improve our own weapon and make it better than our enemy's. But while we do this, the enemy, also, is making his own improvements. So when we bring out a better weapon we dare not rest. Even before we see his answer to it we must drive ahead for some further improvement. It is an unending process. And while we are making the design changes which will give us a better weapon, we always face a rising demand for the production of the very article which is being improved. We cannot do as we might do in peacetime and stop production altogether while the changes are made. Even though it occasionally seems impossible, we have to maintain an unbroken flow of production at the very time when we are changing models.

A CHALLENGE TO ENGINEERS TO EXERCISE INGENUITY

That explains the great and challenging responsibility which rests upon us as engineers and technicians. It is a responsibility which we cannot escape. No cheering news from the fighting fronts can lighten it. No optimistic belief that the end of the war is approaching can entitle us to relax for an instant. For the pace of the war itself is set by production; and the pace of production, in turn, depends upon our ingenuity, our resourcefulness, our inventiveness, and our unflagging competitive spirit. No matter how well we do, we will not come to a point where we can say we have done well enough. The engineer bears the sobering, compelling responsibility that comes to men who are swinging open a great door in human history. His satisfaction can only be the satisfaction of the doer who knows that somewhere within himself he can find the resources to meet the challenge.

We have talked, so far, about winning the war. We know that we are going to win, although we do not know whether the victory will come soon or late. We know what our responsibilities in wartime are. Can we drop them when peace comes, or will they simply become a slightly different kind of responsibilities as compelling as those we now bear?

Winning the war, as I see it, is only half the job. The peace itself must be protected. I do not pretend to know what kind of mechanism should or could be set up among nations to insure the peace, but I believe that I can see where our own responsibility will lie—our responsibility as engineers and technicians.

I believe it will consist very largely in an eternal continuation of the demand for ingenuity and competition which has rested upon us thus far.

That ingenuity and that competitive spirit are being used now to make every ounce of our unlimited potential strength available for war. I cannot believe that once the war is over, the free peoples of this world are going to be content to lapse back into a state wherein they used only a portion of their strength. I believe that they will insist upon being completely healthy fully functioning social organisms. I believe that they will insist that the strength they have be used.

We have at last found out how to make the most of the strength that God gave us and that that strength can be used just as effectively in peacetime as in wartime, and to an infinitely greater gain in human happiness. Look at our own two nations, Canada and the United States, as an example. At this moment we are busy, as never before, making the things of destruction, and dealing stout blows with them. Does one have to be a visionary to believe that when the war is over we should be just as busy, making just as many things for peace, for construction rather than destruction, for life rather than death?

The needs of war, I suspect, can in a large part be traced to the fact that this modern world has not thus far discovered the way to use its own strength and resources in time of peace. There can be plenty all around the globe. People can be busy—*usefully* busy—on every continent, all of the time, if the power which is available to the human race is simply used to meet the age-old needs which the human race has. If those needs are not met, we shall never have a true peace. If, by happy chance, they can be met, then we can build a peace which can last.

It won't be easy. The production strategy of peace will be just as hard to master as the production strategy of war. But by what we have done in the last three years we know that the job can be done; and the pattern which is being set today, in the unending struggle to find new ways of making better things in greater quantity, in the refusal ever to be satisfied with an existing technique or an existing mechanism, that pattern can be carried on to make the peace secure.

It will be possible in the world that lies ahead of us to strike many shackles from the human spirit. By the faith we were born with, we know that if that can be done the possibilities are infinite.

The NATURE *of* PURE METALS[1]

By J. F. YOUNG

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THERE are approximately forty chemical elements of commercial importance which may be classed as *metals*. They are distinguished from nonmetallic elements by *metallic properties* such as good heat conductivity, good electrical conductivity, characteristic luster, and the ability to be permanently deformed to some degree without fracture.

All the common metals are solid at normal (room) temperature except mercury, which is a liquid. They are all some shade of silver-gray in color except copper, which is red, and gold, which is yellow. All of them form alloys, and both the metals and the alloys possess metallic properties and are classed as *metallic materials*.

Only copper, the precious metals, and small amounts of iron (meteorites) occur in the free state in nature. The other metals are always found chemically combined with other elements as ores. The science (and art) of extracting metals from their ores, refining or purifying them, and adapting them to use is known as *metallurgy*. Sometimes this broad field is considered as having two main divisions: process metallurgy and physical metallurgy. These divisions are not clearly defined, but it is usually agreed that process metallurgy deals with the purification and reduction of ores, and the refining, working, and heat-treatment of the metallic materials obtained. Physical metallurgy covers the study of the fundamental nature of metallic materials for the purpose of explaining the various phenomena associated with process metallurgy. The theories resulting from the work of the physical metallurgist point the way for the development of new materials and processing techniques on which progress in the many branches of engineering relies heavily.

An understanding of physical metallurgy is necessary to both the designer and the manufacturer. To the designer, so that he may be guided in the selection and effective utilization of materials; and to the manufacturer, so he will appreciate the purpose and exactness of processing techniques and avoid waste and spoilage due to misuse of material.

THE STRUCTURE OF METALS

The Atom. In chemistry, all matter is said to be made up of molecules, each molecule containing a number of smaller units called *atoms* which are present in some arrangement characteristic of the molecule. The functioning units in metals, however, are found to be monatomic, that is, single atoms. For that reason, metallurgists consider the atom to be the fundamental unit of metallic material, and the term "molecule" is not used in discussing metallic structure.

For most purposes in physical metallurgy, it is convenient to think of the atom as a functioning unit of very small size, shaped something like a ball. Occasionally it is helpful to use the physicists' picture of the atom as being composed of a heavy nucleus, which contains most of the mass, and a sphere of electrons which forms the ball-like exterior. These electrons are in motion in special orbits, the motion being changed in some manner by changes in temperature, and the orbits being somewhat modified by the presence of other atoms.

Liquid Metal. In liquid metals the atoms may be considered as constantly in random motion throughout the volume of liquid and restrained in their motion only by their neighbors and by the walls of the containing vessel. The higher the temperature, the more rapid the motion, until at the boiling point the atoms break the surface-tension forces and leave the surface of the liquid as vapor. Most metals boil at temperatures above those used in common metallurgical practices, but such metals as mercury, zinc, cadmium, and arsenic are exceptions. The boiling point of mercury is low enough that the properties of its vapor may be successfully utilized for power generation in a vapor turbine. Zinc vaporizes at a higher temperature than mercury, but distillation of zinc vapor as a method of refining the metal is possible on a commercial scale.

Solidification. As a liquid metal cools, the motion of the atoms becomes slower and slower until the *freezing point* is reached. At this temperature, the *random* motion of the atoms stops, and they take fixed locations with regard to one another, forming a solid metal. All the atomic motion does not cease as a result of solidification, but that motion which persists is confined to vibration within these fixed locations. A further decrease in temperature will cause some modification of this atomic vibration in keeping with a lower energy state.

If the heat removed during freezing is removed at a constant rate, the cooling curve (temperature vs. time) will be similar to that shown in Fig. 1. Cooling of the liquid is indicated by the line from point 1 to point 2. At point 2 freezing begins, and constant temperature is maintained until freezing is complete at point 3. Continuing the removal of heat from the now solid metal causes the drop in temperature 3 to 4. Note that during the time interval 2–3, the temperature remained constant although heat was being removed at a constant rate. The heat energy given up during this interval is called the latent heat of fusion. It is supplied by the atoms as they take up fixed positions and lose their kinetic energy of random motion.

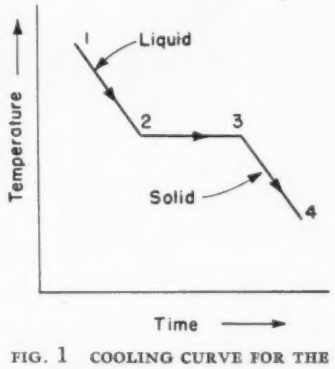

FIG. 1 COOLING CURVE FOR THE FREEZING OF A PURE METAL

Solid Metal. The atoms of the solid metal are held together by interatomic forces due mainly to the electrons. These forces are greater in some directions than in others; consequently, the atoms arrange themselves in geometric patterns called *space lattices*. Each metal always forms its own type of atomic space lattice when allowed to cool from the molten state; and since the lattices are orderly in nature, it is possible to find in them a simple configuration of a few atoms which is repeated over and over again. Such simple configurations are called *unit cells*.

Although there are fourteen known lattice configurations for metals, the majority of them crystallize according to only three types. They are body-centered cubic, face-centered cubic, and close-packed hexagonal. Table 1 gives a list of several metals and the lattice types to which they belong at room temperature.

The unit cell of the body-centered cubic structure has an atom in each corner of a cube and one in the center, as illustrated in Fig. 2*a*. The atoms should not be pictured as concentrated at

[1] Prepared with the assistance of the Schenectady Works Laboratory and the Research Laboratory, General Electric Company.

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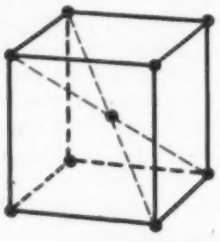
these positions, but rather as having their centers of activity located there, and their spheres of influence being packed close together as illustrated by the model made from ping-pong balls, Fig. 2*b*.

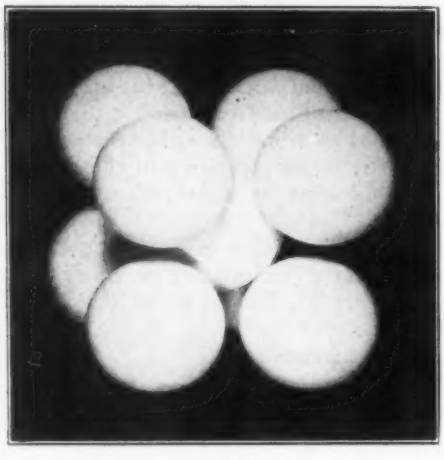
The unit cell of the face-centered cubic structure has, as the name indicates, an atom located in the center of each face, as well as one in each corner of a cube, but none at the center. This arrangement and the corresponding ping-pong-ball model are illustrated in Figs. 3*a* and 3*b*.

The third common lattice form is the close-packed hexagonal structure shown in Fig. 4*a*. This unit cell is a hexagonal prism



(*a*)

FIG. 2 UNIT CELL OF THE BODY-CENTERED CUBIC STRUCTURE
(*a*) Sketch showing location of atom centers; (*b*) ping-pong-ball model



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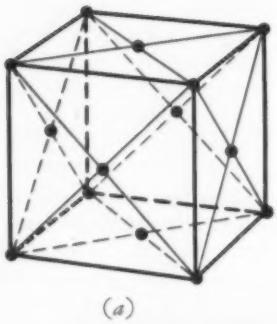
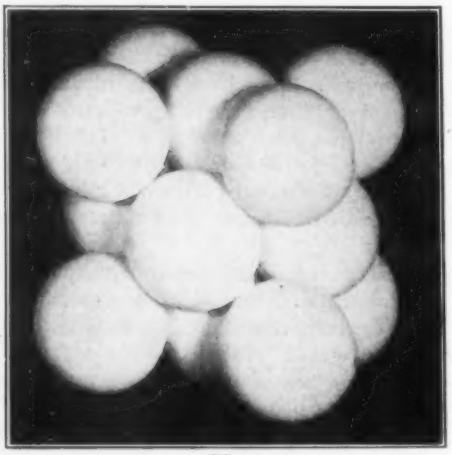


(*a*)

FIG. 3 UNIT CELL OF THE FACE-CENTERED CUBIC STRUCTURE
(*a*) Sketch showing location of atom centers; (*b*) ping-pong-ball model



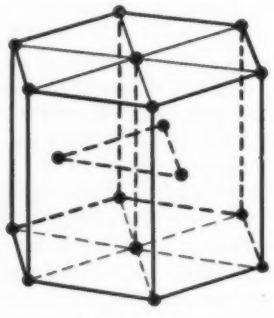
(*b*)

TABLE 1

Body-centered cubic	Face-centered cubic	Close-packed hexagonal
Chromium	Aluminum	Beryllium
Iron	Copper	Cobalt
Molybdenum	Gold	Magnesium
Tantalum	Lead	Titanium
Tungsten	Nickel	Zinc
Vanadium	Platinum	Zirconium
	Silver	

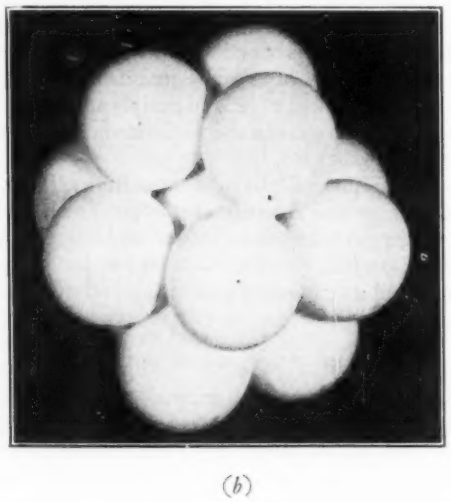
with atoms in the corners and the center of the hexagons formed by the top and bottom planes and three atoms equally spaced in the center of the prism. The model of this unit cell, Fig. 4*b*, was constructed without the top plane so the packing of the three center atoms could be shown.

These unit cells may be considered as the effective building blocks of which the solid metal is built, much the same as



(*a*)

FIG. 4 UNIT CELL OF THE CLOSE-PACKED HEXAGONAL STRUCTURE
(*a*) Sketch showing location of atom centers; (*b*) ping-pong-ball model with top hexagonal plane removed and an extra cluster of three center atoms below



(*b*)

bricks are the building blocks of which walls are built. In the solid metal the unit cells are associated in such a way that the atoms are shared by the neighboring unit cells. In a cubic lattice, for example, eight neighboring cells share a corner atom. The unit cell size is characteristic of the metal, but all are very small (on the order of 3×10^{-8} cm on an edge). Millions of them placed side by side and extending in all directions are required to form a *crystal* of metal.

The continuous orderly arrangement of atoms in a crystal makes it possible to pass imaginary planes through common atoms of a large number of unit cells. The cube plane, for instance, is parallel to one face of a cubic unit cell and contains cube face atoms of many connected unit cells. Planes passed through the crystal so as to contain common atoms of many unit cells are referred to in general as atomic planes.

ALLOTROPIC MODIFICATIONS

A number of metals exist in one crystal lattice form over a range of temperature, but at a certain critical temperature the

lattice form changes to another type which is stable over another temperature range. Such metals are said to be *allotropic* and the change from one type of crystal lattice to another is referred to as an *allotropic change*. These different lattice forms are, of course, identical by chemical analysis, but they usually possess widely different physical properties.

Iron is the most familiar example of an allotropic metal. In Table 1 it is listed as having a body-centered cubic unit cell. This type of structure is retained up to 910 C, but above that temperature the iron changes to a face-centered cubic type of unit cell. In turn, this structure changes back to the body-centered cubic type at 1400 C and the metal melts at 1535 C.

THE GRAIN STRUCTURE OF METALS

During solidification, the atoms of the liquid metal start to freeze by forming a unit cell which acts as a nucleus for further solidification. If no other nuclei form, this single unit cell will grow continuously as atoms of the liquid metal attach themselves to it, gradually building up the space lattice until all the metal has solidified. If this occurs, the metal will be a single crystal in which all the atomic planes are parallel to those of the original unit cell which acted as a nucleus. Such single crystals have been produced in large sizes, e.g., several inches in diameter and a foot long. However, with the usual rates of cooling, the solidified metal is generally composed of thousands of crystals, each different in orientation from its neighbors. Each of these crystals started from a unit cell and grew until it met its neighbors, which were, of course, growing from other nuclei. The number of crystals (more commonly called *grains* in metals) that form depends jointly on the rate at which the nuclei form and the rate of grain growth. The more nuclei forming simultaneously from the liquid, the greater the number of grains, that is, the smaller the grain size. Again, the slower the rate of grain growth, the smaller the *grain size*, provided the rate of nuclei formation is moderate. It is conceivable that the rate of grain growth could be so high that, regardless of the rate at which nuclei form, the whole melt would solidify in a few grains. However, the rate of grain growth is usually low enough so that the rate of nucleation has a predominant influence on the grain size. The rate of cooling, in turn, determines the rate of nucleation; rapid cooling therefore usually results in the formation of many small grains, and slow cooling produces fewer but larger grains.

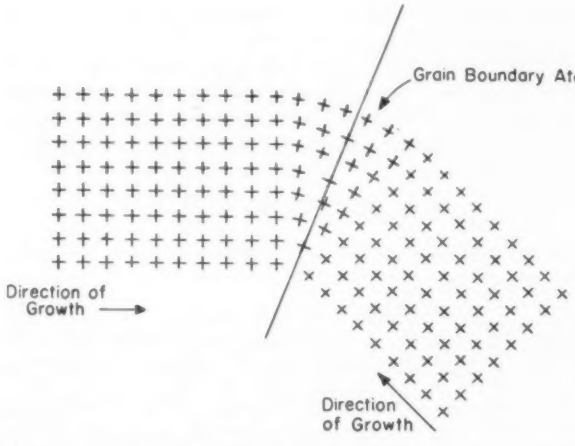


FIG. 5 SCHEMATIC DIAGRAM OF ARRANGEMENT OF ATOMS AT GRAIN BOUNDARY. CROSSES INDICATE ATOM POSITIONS

When two adjacent grains grow together during freezing, the atoms of the last liquid to solidify are mutually attracted to both grains. Since the orientations of the two grains differ (otherwise they would unite and become one), these atoms cannot form on either lattice but must occupy compromise positions as shown in Fig. 5. The region between grains which contains these displaced atoms is called the *grain boundary*. Grain boundaries interrupt the continuity of the lattice planes and greatly increase the resistance of the metal to cold deformation; hence, a small grain size is desirable in a metal which must support an applied load.

MICROSCOPIC ANALYSIS

Optical Microscope. Most grains in metals are too small to be seen by the naked eye, so they are usually magnified by an optical microscope for the purpose of study. The image visible in the microscope may be photographed to record the appearance of the structure for subsequent analysis. Such photographs are called photomicrographs. Although it is not essential that the engineer be able to take these photomicrographs, a proper interpretation of them will help him to visualize the grain structure of a metal. It will also enhance his ability to work with the metallurgist. A short discussion of microscopic analysis is therefore appropriate at this point.

Before specimens of metal can be microscopically examined, they must be polished to an optical flat so that the whole section under the microscope can be enlarged in focus. A large magnification is involved and this, together with the work associated with the polishing operation, makes it best to use small specimens. There seems to be practically no limit to the minimum size used, for samples as small as a few microinches across have been examined successfully. The maximum size, however, usually does not exceed one inch in width (either square or round cross section) and three-fourths inch in length. After the sample of the region of interest is cut within these limits, it is mounted in a piece of plastic or other suitable mounting medium and the polishing operation is begun. This operation consists of three steps:

(*a*) Grinding, usually by emery or carborundum wheels.
(*b*) Rough polishing by fine emery papers to remove the markings or scratches left by the emery or carborundum wheels.
(*c*) Fine polishing or lapping with a very fine polishing powder to remove the fine scratches left by the rough polishing. Usually fine wet alumina powder is used on rotating disks covered with broadcloth or felt.

The polishing operation leaves the specimen with a mirror-like finish and if it were to be examined under the microscope, it would show merely a mirror reflection of the light source. If inclusions or cavities were present in the surface of the specimen, they would be distinguishable because they reflect light differently than does the polished surface.

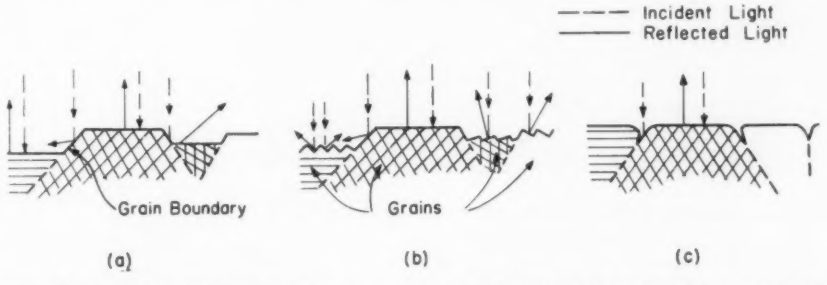


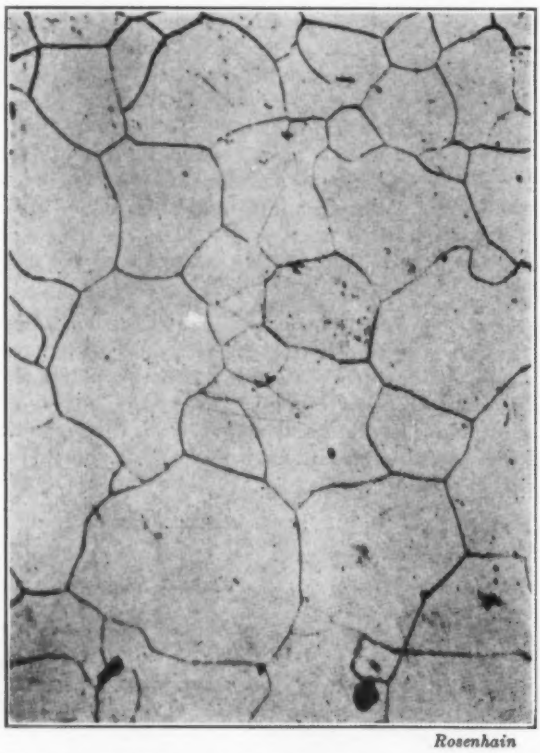
FIG. 6 SKETCH SHOWING EFFECTS WHICH MAY RESULT FROM ETCHING A POLISHED SURFACE, AND MANNER THAT ETCHED MATERIAL REFLECTS INCIDENT LIGHT

[(*a*) Grains attacked at different rates, grain surface optically flat; (*b*) grains attacked at different rates, grain surface optically rough; (*c*) grain boundaries attacked, grains almost unaffected.]

In order to distinguish individual grains, the polished surface of the specimen is etched with a suitable reagent. Several of

the reagents used attack the grains more rapidly in some directions than in others, and so the orientation of the grains with respect to the polished surface will make a difference in the degree it is attacked. As a result, the originally flat surface, when etched, may have different "levels" for grains of different orientations, somewhat as shown in Fig. 6*a*. In pure metals, the exposed surface of each grain is usually optically flat (that is, the imperfections are smaller than the wave length of light), but they may be "rough" as indicated in Fig. 6*b*. The roughness depends upon the reagent and the grain orientation. For some metals a reagent may be chosen which will attack the grain boundaries more rapidly than the center of the grains, and by controlling the degree of attack, tiny "valleys" may be produced at the grain boundaries before the center of the grain is appreciably affected. This effect is illustrated in Fig. 6*c*.

The grain boundaries may be detected on any of these surfaces when the specimen is viewed with the microscope. Briefly this may be explained as follows. The light from the microscope is directed perpendicularly to the surface of the specimen. If the etchant has produced a surface such as that of Fig. 6*a* the light striking each grain will be reflected back into the microscope at nearly full intensity, and the grains will be uniformly white. The grain boundaries will be dark by contrast because the light striking them will be reflected outside the microscope. The photomicrograph, Fig. 7, shows the grain



Rosenhain

FIG. 7 PHOTOMICROGRAPH OF THE GRAIN STRUCTURE OF IRON (Approximately ×100.)

structure at high magnification of a pure metal etched in this way. Note that the grains are not necessarily uniform in size or shape.

If the surface is like Fig. 6*b*, in which the surfaces of the grains are not optically flat, the grain boundaries will appear dark, as before, but the grains will be shaded from white to dark. The difference in shade of these grains is due to the relative amount of light that is reflected outside the microscope by the tiny roughened planes on the exposed surface of a grain.

The separate grains of a surface like Fig. 6*c* will appear uniformly white because they are lightly etched. The grain boundaries will appear dark by contrast because the light striking them will be partially absorbed (as a result of multiple reflections) in the tiny "valleys" and partially reflected outside the microscope.

At present, the customary working range of the optical microscope is from 100 to approximately 2000 linear magnifications. It is frequently used at higher magnifications, however, for specific purposes.

Electron Microscope. The electron microscope is a recent development in which an electron beam instead of visible light is used for inspecting samples. The beam of electrons cannot be reflected from a metal surface, as is a light beam, consequently, the examination of polished and etched metallographic specimens is done by the use of a transfer technique. A thin film of plastic material (which is partially transparent to the electron beam) is cast on the surface of the etched specimen to take its contour on the contact side. This film remains flat on the free or top side. After it solidifies, it is stripped off the specimen and placed in the electron beam for examination. The electrons pass through the film, are diverged for magnification (by either electromagnetic or electrostatic fields), and finally fall on and expose a photographic plate. For visual examination, a fluorescent screen is used in the place of the plate. Differences in levels produced by etching may be detected because the degree of transparency of the film varies with its thickness. This type of microscope shows promise for metallographic examination of transfers at magnifications up to 50,000 times.

REFINING AND FORMING METHODS

There are three ways in which metals are refined from their ores. They are:

(*a*) Furnace reduction involving chemical reaction.
(*b*) Furnace reduction involving condensation of vapor.
(*c*) Electrolytic deposition from partially refined ore.

The latter two methods are economically useful for only a few metals. Condensation from the vapor is used for refining mercury and zinc, and electrolytic deposition is used for refining aluminum, magnesium, copper, nickel, and some other metals.

The metals obtained by these methods of refinement may be molten, solid, or powdered. The first operation for putting them into form for their use may be either[2]

(*a*) pressing and sintering metal powders or, more commonly,
(*b*) casting from the molten state into a suitable shape.

Pressing and sintering consists of pressing finely powdered metal into a mold of the desired shape, then heating the pressing in a nonoxidizing atmosphere to a high temperature to sinter or weld the particles together. The actual tonnage of metal prepared in this way is rather small and the applications rather specialized, but important.

By far the greater tonnage of metal produced is refined in a furnace and cast from the molten state. Some may be cast into the final form in which it will be used (for instance, sand, die, and plaster-of-Paris castings), but more frequently the metal is cast into ingots which are later rolled, forged, drawn, extruded, or hammered into various shapes such as large cylinders (forgings for turbine shafts, gun barrels, etc.), thin sheets, plates, rods, bars, rails, wires, etc. Metals furnished in these shapes are known broadly as *wrought* metals.

GRAIN STRUCTURE IN CASTINGS

Pure metals are frequently cast as ingots and wrought to final form, but very rarely are they used as cast shapes. Even so, it seems appropriate to include an explanation of how grain structures peculiar to castings are obtained.

In the foregoing discussion of solidification, it was assumed that heat was removed uniformly from all the molten metal. Nuclei were then formed throughout the melt, and the grains

[2] These methods apply also to alloys.

tended to be of the same size and of nearly equal dimensions in all directions, and no special alignment was noticed. In a casting it is not possible to cool all the melt uniformly because the heat must be removed through the wall of the container or mold. This causes the metal in contact with the wall to freeze first, and solidification proceeds toward the center from nuclei formed in the vicinity of the walls.

If the number of nuclei formed is large, grain growth along the wall will result in many intersections, and the grain size in this direction will be small. The growth toward the center of the liquid is not apt to be restricted so much by intersection with other grains because the heat energy is being removed through the solid metal at the wall, and the nucleation in the liquid is therefore limited. As a result, when freezing is complete, the grains are very long in directions perpendicular to the walls of the container. Grains of this type are called *columnar* grains. This effect is most pronounced in chilled thick sections.

Columnar grain growth is particularly undesirable in ingots which have square corners because planes of weakness are established at the intersections of the columnar grains. These planes nearly bisect the corner angles, as shown in the photograph of the cross section of a copper ingot, Fig. 8, and they reduce the mechanical strength of the ingot, making it susceptible to fracture during working. To minimize their formation, corrugated ingot molds with round corners are used. They cause the columnar grains to grow in all directions as illustrated schematically in Fig. 9.

This figure also illustrates another effect which occurs when metal is cast. The solid metal next to the mold contracts as it cools, and the change in volume is made up from metal of the still-liquid center of the casting. As the last metal solidifies, however, there is no more liquid to flow in and make up the contraction, and the *pipe* (the hollow section at the top of the casting) results. Various ingot forms have been used for different metals to obtain a shallow pipe.

If the cast metal is cooled slowly enough to give rather large grains at the center of the casting, these grains will be regular rather than columnar in shape. Within both types of grain shapes a structure known as *dendritic or pine-tree structure* may occur. It occurs to some degree in most castings and is caused by preferred directional growth. Such growth is a natural characteristic of metals since it is easier to add atoms to the unit cells in certain planes than in others. During solidification, the more rapid growth in the preferred directions results in a skeleton crystal formation (the dendrite) which contains many interstices filled with melt. These liquid areas freeze last, and their contraction causes small regions of elastic strain which contribute to somewhat reduced ductility in the cast metal as compared with the same metal treated mechanically and thermally for highest ductility. The dendrites may also be outlined by impurities, or, in the case of alloys, by other structural constituents present, and this is known as *dendritic segregation*.

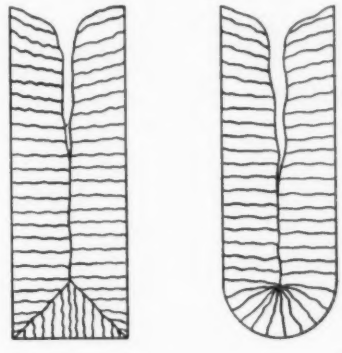


FIG. 9 SKETCH SHOWING EFFECT OF SQUARE- AND ROUND-BOTTOM CORNERS ON SMALL INGOT MOLD. PIPE IS ALSO SHOWN

In casting pure metals and alloys into shapes or ingots, the columnar growth and formation of dendrites can be modified by choice of mold shape and control of grain size. It is emphasized, however, that the degree of occurrence of columnar grains and dendrites in alloy castings is largely a function of the composition of the alloy. Proper alloying and casting technique therefore render these effects subject to control.

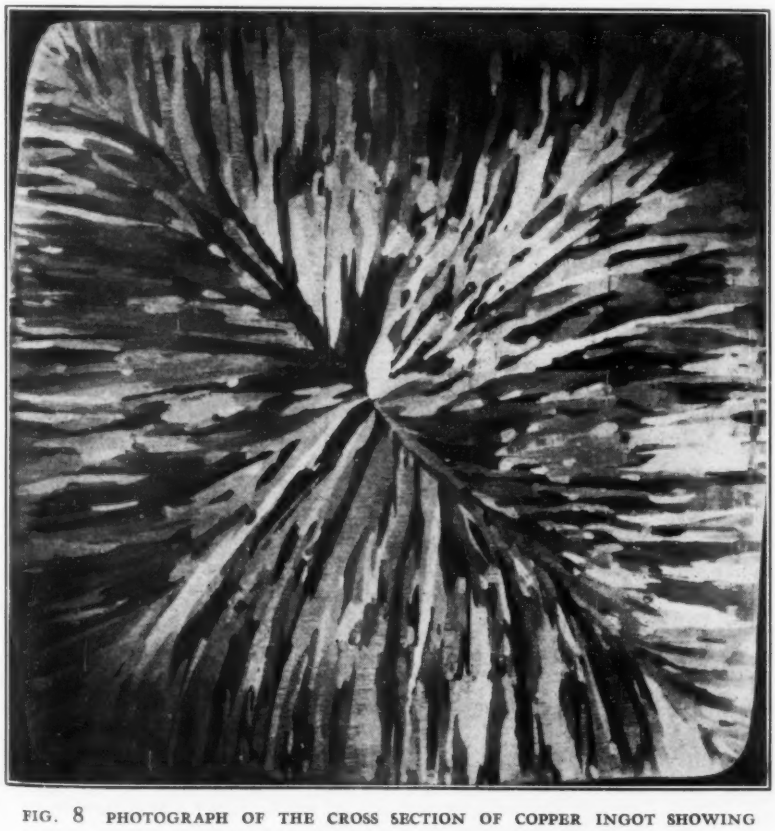


FIG. 8 PHOTOGRAPH OF THE CROSS SECTION OF COPPER INGOT SHOWING COLUMNAR GRAINS AND PLANES OF WEAKNESS

COLD WORKING

Cold working refers to the act of permanently deforming a "cold" metal. The term "cold" is relative, and even room temperature may be "hot" for some metals (e.g., lead) as will be shown in the section dealing with recrystallization.

During cold working, two kinds of deformation occur. One is simply *elastic* distortion which is recoverable after removal of the load causing the disturbance. The other is *plastic* deformation, caused by loads greater than the limit of the elasticity of the metal. Such deformation is permanent and causes changes in shape and in the structure and properties of the metal. No cold working is done without causing this type of deformation.

PLASTIC DEFORMATION

If a metal has been plastically deformed by cold work, the space lattice of each of its grains is partially distorted. Apparently, the deformation has taken place by the slipping of parts of the grain over one another, similar to the sliding of cards in a deck There are several combinations of planes of atoms and directions of slip that can function in a crystal, but the most favorable planes are those containing the greatest number of atoms, and most widely spaced in the grain. The slip takes place along these planes of dense atomic population even though they may not be aligned with the direction of loading, as shown in Fig. 10.

If the polished surface of a metal is viewed under a microscope after plastic deformation, a

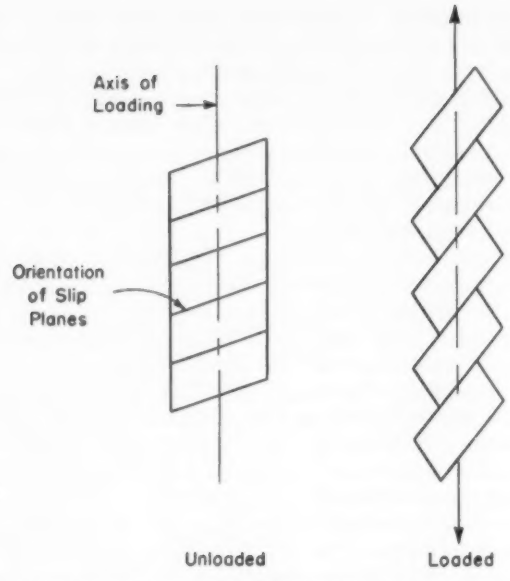
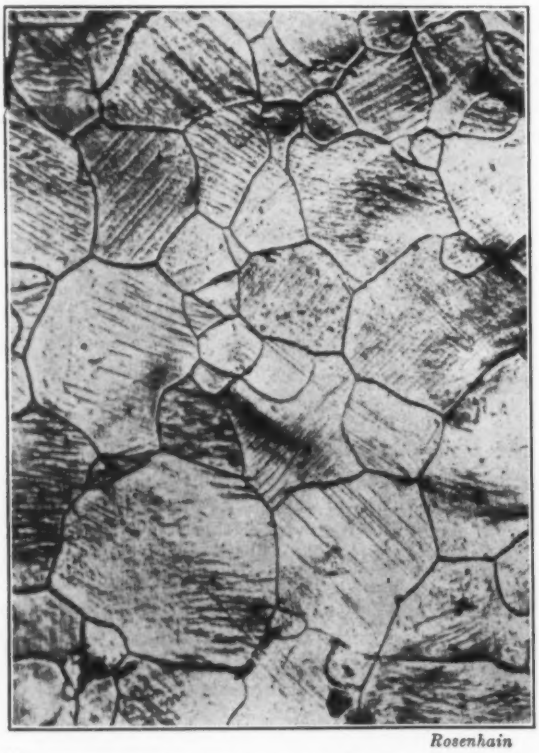


FIG. 10 DIAGRAMMATIC REPRESENTATION OF SLIP IN SINGLE CRYSTAL



Rosenhain

FIG. 11 PHOTOMICROGRAPH OF IRON SAMPLE IN FIG. 7 WHEN LOADED TO PRODUCE MINUTE AMOUNT OF SLIP (Approximately ×100.)

series of parallel lines will be noticeable on each grain (see Fig. 11). These lines are slip lines or slip bands, and they are caused by a series of steps such as are shown in Fig. 10, but not so pronounced.

STRAIN HARDENING OR WORK HARDENING

As a metal is plastically deformed, it becomes stronger and a higher load is necessary to cause additional deformation. This phenomenon is known as *strain hardening* or *work hardening*. It is usually explained as follows:[3] X-ray diffraction studies of plastically deformed crystal lattices show that the atoms in a deformed crystal are not arranged with absolute regularity as in the undeformed crystal, but instead, the atomic planes are roughened. Apparently, this *roughness* is due to local distortion of the crystal lattice, and in consequence the lattice orientation varies slightly from point to point. The imperfections at the changes in lattice orientation appear to represent local regions of high elastic strain. As deformation proceeds, the irregularity of orientation increases, and greater force is required to cause the distorted planes of atoms to slip over one another. Thus the metal is hardened and strengthened as a result of strain or deformation.

[3] The mechanism described is generally accepted as representing the condition of a metal during deformation, but is not necessarily correct and may be modified as metallurgical knowledge improves.

GRAIN DEFORMATION AND PREFERRED ORIENTATION

With extreme cold working, each grain will be elongated and its atomic planes change direction so that its orientation tends to line up with the direction of working (see Fig. 12). Since

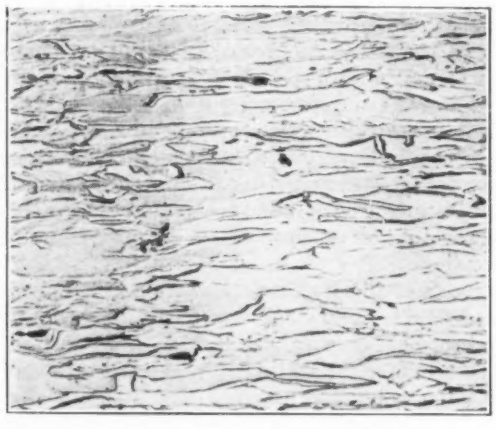


FIG. 12 PHOTOMICROGRAPH OF COLD-WORKED COPPER ×250

the strength, magnetic characteristics, etc. of the crystals of some metals depend on the orientation of the crystal, this tendency to align the crystal lattices causes directional properties. For instance, the cold-worked metal may possess better strength in the direction of alignment than in other directions. Directional properties are sometimes valuable, as in transformer laminations, and sometimes harmful, as in brackets made from sheet bent so the bent edge is parallel to the direction of working.

COLD-WORK FRACTURE

If the plastic deformation due to cold working or service loading is continued far enough, the metal will eventually fracture. The fracture occurs when the lattice distortion has progressed to the point at which the cohesion between atoms is finally broken. Fractures of a metal which result from excessive cold work or short-time loading (at temperatures too low for recrystallization) are therefore transcrystalline, that is, across the grains.

RECRYSTALLIZATION

After a metal has been plastically strained, as by cold work, it is subject to recrystallization if heated and held at a high enough temperature for a long enough time. By recrystallization is meant the formation of new, unstrained grains of nearly equal dimensions in all directions (equiaxed).

Three chief factors must be considered in recrystallization. They are time, temperature, and amount of previous cold plastic deformation. A general rule is: *The greater the amount of cold work done upon the metal, the lower is the temperature at which recrystallization occurs*. Factors which tend to lower the recrystallization temperature are increased time at a given temperature, smaller grain size prior to cold work, lower temperatures during cold work, and greater purity of the metal. Under the most

favorable conditions there is a practical "lowest temperature" of recrystallization below which recrystallization will not occur except for very long periods of time. The practical, short-time "temperature of recrystallization" for some common pure metals is given in Table 2.

TABLE 2 PRACTICAL SHORT-TIME TEMPERATURE OF RECRYSTALLIZATION FOR SOME COMMON PURE METALS

Tungsten	1200 C	Silver	200 C
Tantalum	1000 C	Aluminum	150 C
Molybdenum	900 C	Magnesium	150 C
Nickel	600 C	Zinc	Room temperature
Iron	450 C	Cadmium	About room temperature
Platinum	450 C	Tin	About room temperature
Copper	200 C	Lead	Below room temperature
Gold	200 C		

One great value of recrystallization is that metals can be formed to a much greater extent and more economically by its use. In deep-drawing operations, metals would become too hard to cold work and would fracture on further cold shaping if a recrystallization operation (annealing) were not used after a certain amount of cold work. This operation results in small, randomly oriented, equiaxed grains capable of being cold worked again. The deep drawing can thus be carried to completion by alternate straining and recrystallization.

Recrystallization may also be used in conjunction with cold working to refine coarse cast grain structure in an ingot.

ANNEALING

The term *annealing* is applied to the operations in which a metal is heated for the purpose of restoration of a fine, unstrained, equiaxed grain structure by recrystallization. Naturally, the full anneal requires a temperature as high or somewhat higher than the recrystallization temperature and time is a co-operative factor. Stress relief may be accomplished by heating to temperatures below that for recrystallization. This treatment restores the atoms into an undistorted lattice, but does not cause the formation of new grains.

GRAIN GROWTH

Just after a metal has recrystallized, the grains are small and regular in shape. If the temperature is high enough or if the time at temperature is allowed to exceed the minimum required for recrystallization, the grains will grow. This growth is the result of a tendency to return to the most stable state, which is ultimately one single large grain. The grains that are slightly larger than their neighbors grow at the expense of their neighbors until the small grains are all gone and only a few large grains remain.

The mechanism by which this growth occurs is thought to be as follows: The atoms in the grain boundaries are in a state of strain (high energy state). When the metal is heated to a high enough temperature, these atoms have enough mobility to align themselves with a crystal lattice. Because of the tendency to return to the most stable (low energy) state, they line up with the larger grain. The change from one grain to another may be thought of as movement of the boundary zone into the smaller grain, thus making the small grain smaller and the larger grain larger. This process continues until the small grain is absorbed by the large grain.

For any temperature above the recrystallization temperature, normally there is a "practical maximum size" at which the grains will reach "equilibrium" and cease to grow appreciably no matter how long they are held at temperature. There are, however, certain cases of abnormal grain growth which occur as a result of applied or residual gradients of strain due to nonuniform cold work or nonuniform impurity distribution, and which permit growing very large single grains.

It should be noted that the grain structure of a pure metal which has no allotropic transformation, e.g., copper, cannot be refined without first cold working the metal into the range of plastic strain. Even then, the metal must be heated to or above the recrystallization temperature, and heating discontinued before excessive grain growth occurs. Merely heating a pure metal which contains no plastic strain and is not allotropic will only cause grain growth, and not recrystallization.

HOT WORKING

Hot working is done in the same manner as cold working except at a high enough temperature so that recrystallization takes place simultaneously with straining, thus recrystallizing the metal even before it can effectively work harden.

There is, of course, the danger of grain growth at temperatures above the recrystallization temperature. If the hot-working schedule is carried out in such a way that the metal reaches the recrystallization temperature on cooling about the same time that the plastic working is finished, the minimum grain size will result. If working is stopped at too high a temperature, grain growth will occur during cooling, thus nullifying the refining effect of the hot work. If, on the other hand, hot working is carried on too long and the metal cools below the recrystallization temperature, cold working would be effected.

The term "hot working" may apply to some operations where there is no heat applied at all (see Table 2). For instance, for lead, tin, and zinc, room temperature is at or above the recrystallization temperature, and these metals can be "hot worked" without the addition of heat. On the other hand, tungsten can be "cold worked" at a temperature of 1000 C, which is still below its recrystallization temperature. The chief objective of hot working is economic and efficient shaping. Refinement of the grain is usually only a secondary objective.

HOT WORK FRACTURE

If the metal is fractured during hot working or during short-time loading at elevated temperatures, the fractures will not occur across the grain as for a short-time cold-work fracture, but instead will follow the grain boundaries. This occurs because at the hot-working temperature the grain boundaries are weaker than the grains and the metal fails when the cohesion between the atoms in the grain boundary is exceeded.

This intergranular type of fracture occurs when the load has been applied for a short time only when the temperature is considerably above that for recrystallization. Such a fracture may also occur at temperatures nearer the recrystallization temperature with loads much less than the short-time tensile strength if the load is applied for a long time. Apparently, movement or flow of the atoms in the direction of the load takes place at most any temperature and load and, at high temperature, when sufficient time is allowed, the elongation continues until failure. This phenomenon is known as *creep*.

CONCLUSION

The basic characteristics of pure metals have been briefly considered. Most metals prepared commercially contain some small percentage of impurities, be it as little as 0.001 per cent. Although these impurities may have a great effect on the magnitude of the properties of the metal, it should be noted that the various types of grain structure and the characteristics such as cold work, slip, strain hardening, recrystallization, annealing, grain growth, hot working, fracture, and creep also define the behavior of these impure metals.

The information given has been based upon the most up-to-date theories in the science of metallurgy. All theories, however, are valid only so long as they explain the observed phenomena in a satisfactory manner. In the future, it can be expected that more satisfying explanations of some phenomena will be presented as more exact information on the nature of atomic structure is obtained. Meanwhile, the existing theory will form an adequate working tool.

MANAGEMENT ASPECTS *of* SAFETY ENGINEERING

By FRANK E. FAAST

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EXPENDITURES for improvement of plant from a management standpoint are usually justified only if they increase the income of the plant. One type of profit-producing improvement that has tended to be generally overlooked both in the present rush of war production and in our recently departed depression is safety devices and other safety measures. While it is true that some such expenditures are a loss in that they may show no tangible returns, a large proportion of them can be very real although not plainly obvious investments and produce substantial savings in different forms.

It is the purpose of this paper to point out certain shortcomings of management in failing to develop the possibilities in the profitable use of safety measures; to investigate some of the reasons therefor; and finally to offer some suggestions for improving the situation.

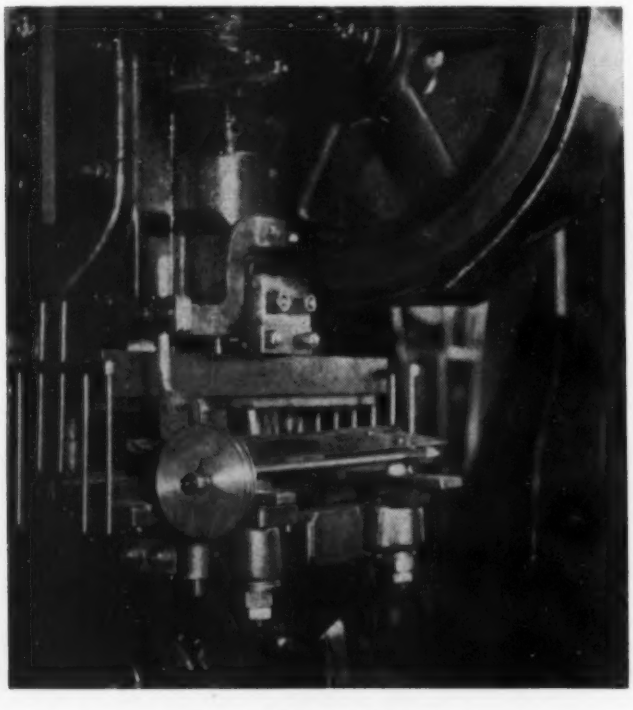
BENEFITS DERIVED FROM INSTALLING SAFETY EQUIPMENT

In general, industry has had the tendency to install safety equipment only as a measure of compliance with requirements of state and other factory and labor laws. After such equipment has been installed, it has often been found that fewer accidents occurred, more and better quality production resulted, compensation-insurance premiums were reduced, and expenditures in satisfaction of judgments in personal-injury suits have been lowered. In other words, the equipment may bring about large savings. The author has seen several instances where the savings to be gained by use of safety devices were so easily apparent at the time their need was pointed out, that from the standpoint of good business alone the respective managements should have been censured for having failed to effect the savings long before it became necessary to point out the shortcomings to them.

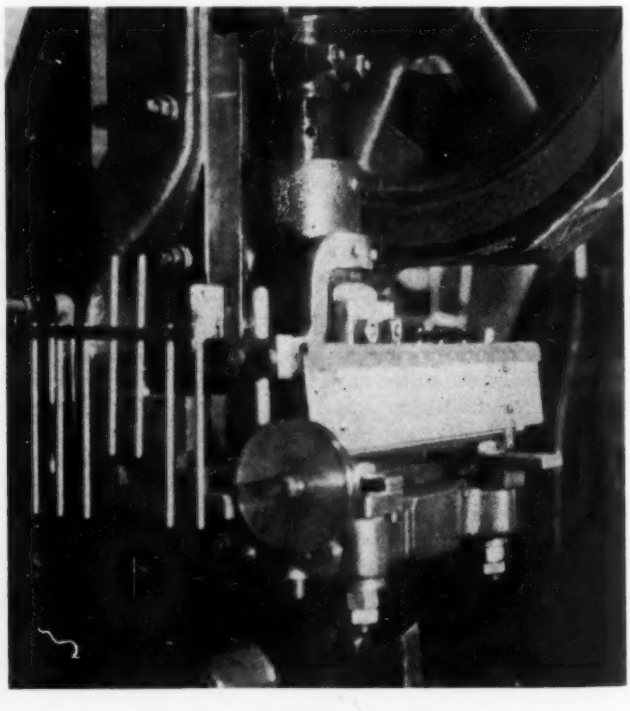
In many cases safety equipment is not utilized, or machines are designed without regard for safety of the operators because its use would tend to reduce the speed of the operator or of the machine. Great care should be exercised that apparent gains from machine speed are not outweighed by excessive cost of casualties.

A factor seldom taken into account is the effect of frequent casualties on morale of personnel. With present-day long hours of work under tension, when an employee suffers a major injury fellow workers in the same plant or department tend to become depressed and jittery to the extent that it often becomes dangerous to allow them to continue their operations around moving machinery, both because of the possibility of injury to themselves and to expensive machinery. Other employees become overcautious and slow down production, while still others absent themselves from work for the following day or two to get over their nervousness. The result is that production is interrupted and costly delays may occur. Personnel may become discontented and labor turnover increase. Neither this nor absenteeism can be afforded today.

Contributed by the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.



PUNCH PRESS WITH RAM UP



SAME PRESS WITH RAM DOWN

(With ram down, flipper-type guard covers die front, while basket-type guard covers ends, making it impossible for operator to have hands in die. Photographs by courtesy of J. A. Rennie, New York, N. Y.)

GOOD LIGHTING PAYS DIVIDENDS IN PRODUCTION

A much neglected consideration is good lighting. Those who foot the bills dislike to spend any more money for lighting than they consider necessary to achieve production. However, correct lighting will usually pay for itself quickly in reduced casualty toll and by improvement in quantity and quality of production.

It is important that employees engaged in dangerous operations remain wide awake at all times. A great danger which must be carefully guarded against (although it may be easily corrected or reduced when discovered to exist) is the tendency for monotonous repetitive operations in poorly lighted environments to dull a machine operator's sense of alertness in a surprisingly few minutes. If there is any doubt about this, remember that the chief prerequisites of sleep-inducing hypnosis are repetition and a limited amount of light; or recall how often and in how few minutes you have observed a monotonous speaker actually put a substantial portion of his audience to sleep.

If safety appliances and good lighting will pay profits, why does not management take greater advantage of them? Some of the answers are simple, others rather complex.

Institution of a safety education program in your plant, instead of expensive foolproof devices, may sound like the low-cost solution of many difficulties. But do not leave safety practices entirely up to the individual employee. Teach him to be careful, but then plan on his being only reasonably so. The most reliable and careful workmen may not be entitled to occasional lapses into carelessness, but they will lapse anyway. And human nature being what it is, the better part of wisdom is to figure on it. For piece work employees, do not count at all on safety education.

JUSTIFYING THE COST OF SAFETY DEVICES

In general there can be no argument with the plea of lack of capital, although in some cases the cost may really be excessive. However, even if funds are available, chances are against their

HERE'S WHAT A FEW LAMPS AND A COAT OF PAINT CAN DO. THERE ARE MANY "DAYTIME" SHOPS WHERE SUCH MINOR CHANGES WILL MAKE A SURPRISING DIFFERENCE IN HOW MUCH WORK CAN BE PRODUCED IN A GIVEN TIME

(Photographs by courtesy of General Electric Co.)

being expended unless it can be proved that they will bring a return. This is as it should be. Requests for safety appropriations should as a matter of course be accompanied by a statement and figures showing, respectively, the source and estimated amounts of savings. The engineer who recommends expenditures for safety improvements without backing up his proposals with factual evidence in order to show exactly where the return is to come from is usually rebuffed, unless of course, it happens that his purpose is to comply only with obligatory factory laws.

Appropriations are often withheld for slowly self-liquidating safety measures because of management's understandable tendency to avoid having investments of this nature charged against plant profits, as the vicissitudes of business may make it desirable at one time or another to be able to show an impressive cash balance on the company books for any one of a great many possible reasons. Furthermore, appropriations may be killed in favor of a high stock dividend for the purpose of creating a favorable position in the credit or stock markets, or for other temporary considerations.

Most plants, however, are insufficiently protected by safety appliances because those responsible either are not fitted by training or experience to see the possibilities in turning dangerous plant conditions into savings, or because they cannot spare the time from their other duties to study the safety situation within their plants.

PRACTICAL APPROACH TO SAFETY PROGRAM

A great difficulty in getting safety programs instituted lies in managerial and ownership inertia and indifference. Suggestions to be made will be directed toward overcoming these, rather than to describing detailed safety practices; as practical difficulties can usually be studied through to a conclusion provided necessary funds are available.

For the purpose of demonstrating the savings to be obtained, it may be well to try out prospective improvements such as better lighting or safety appliances in only one or two departments of a plant. Records should be kept of the initial and maintenance costs of the new equipment, records of production quantities and qualities, possible reductions in the inspection staff due to improved quality of production, and decreased damage to machinery because of more alert personnel. Accident data should also be compiled. All of these records should be compared periodically with previous data to determine whether savings warrant extension of equipment to the remainder of the plant.

Comparisons are often difficult or gains may not be analyzed readily, particularly where the figures may be lumped with other data in the bookkeeping system. In such instances comparisons of performances in similar plants often yield interesting information.

In plants where each executive or employee has his full time occupied with other duties he cannot be expected to spend valuable time studying the safety situation. Eventually, large plants have long found it profitable to engage a safety engineer. In some plants entire safety departments have been organized to do nothing else but that type of work. Where this has been done, in almost every case, the savings have paid several times over for the expenditures. Smaller organizations would do well to call in outside experts at periodic intervals and compensate them perhaps on the basis of a percentage of insurance and other savings.

On the other hand, as previously intimated there is no object in active agitation for initiating safety programs when it is known that the funds will not be available. When an organization hesitates to promote safety measures in order to maintain temporarily high cash reserves for some reason or other, as previously intimated, it may be well to await a more propitious moment. It is possible that the required capital might be better employed in other ways for the time being, good discretion in such matters being, as always, an asset.

There may be what can be called a psychological moment for the plant manager to ask his board of directors for safety-program appropriations; or let us say, for the safety engineer seeking to sell his services. Such an opportunity will often arise when it can be pointed out how safety equipment will pay for itself and more, particularly after the expense of doing without safety equipment has been drastically demonstrated by casualties resulting in increased compensation costs, expensive interruptions to production, dissatisfaction among employees, and so on.

SAFETY IS A JOB FOR THE ENGINEER

It will be said that this business of psychological moments, and the matter of putting safety ideas across to those who hold the purse strings, is not important to engineers as engineers; on the other hand, imagine an engineer or manager trying to cajole his board of directors into making appropriations for safety devices after he has perhaps spent weeks reviewing his plant's safety situation and its related effects on production and overhead costs and as a result knows definitely that his program would be a profitable investment. If it required this trained engineer or manager many weeks to reach his conclusions, how can his ideas and calculations make sense to an unimaginative, nontechnically trained board who may know nothing of the work involved in the study, some of whose members may never have been inside of the plant and whose main interest is large dividends; or to an owner who has so little business experience that he must engage others to look after his business for him? Apparently a carefully considered analysis of safety conditions and costs, resulting in conservative recommendations for protective devices, must mean very little to the men who foot the bills when they elicit comments possibly something like the following: "The floors of such and such a building have not collapsed for 45 years, why reinforce them?"

In the face of such argument, it is often a great convenience to be in a position to point to a spectacular rise in compensation-insurance costs or to other important and recent experiences or events, in order to combat antipathy and disinterestedness. In any case, it is repeated, always when possible show exactly how the company will benefit. Better still, prove it!

TYPICAL PLANT ANALYSIS SHEET

Our plant employs (a)_____productive workers.

Each worker puts in (b)_____hours per day.

Our total daily man-hours are therefore (a x b)_____(c)

If specified changes increase our production rate only 4%,

then we stand to gain:

(c)_____X 4% = _____man-hours per day.

If specified changes decrease our spoilage by only 25%,

then we stand to gain:

(c)_____X(d)_____% X ¼ = _____man-hours per day.

If our spoilage goes down 25%, we stand to conserve the

following material:

(e)_____X(d)_____% X ¼ = _____conserved.

If specified changes reduce our accident rate* by one third,

then we stand to save:

(f)_____X 1/3 = _____man-hours per day

(d) = Our average % spoilage.

(e) = Our daily material requirement.

(f) = Our daily man-hour losses due to accidents.

* = Hidden losses due to accidents--usually 2 to 3 times reported loss, due to interruptions to schedules, etc.

MANAGEMENT PROBLEMS *in* JUDGING *Quality* CONFORMANCE *in the* INSPECTION FUNCTION[1]

By J. M. JURAN

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FACT FINDING DISTINGUISHED FROM JUDGMENT OF CONFORMANCE

IN inspection of manufactured product, the basic inspection act includes a comparison between the inspector's measurement of the product with the inspector's interpretation of the quality specification. The measurements and observations made by the inspector are all in the nature of fact finding. The judgment as to whether, in the light of these facts, the product conforms to the specification is a problem quite separable, in theory, from the problem of fact finding. Such separation of the problem of fact finding from the problem of exercising judgments is quite common in many areas of human endeavor. Our legal system, for example, makes a clear distinction by giving to the jury the function of fact finding while reserving to the judge the function of judging conformance with the law in the light of such facts.

For maximum precision and for a minimum of human differences, industry has gone far to minimize the extent of human judgment entering into determination of quality conformance. One of the important reasons for providing gages and testing equipment is to minimize the amount of personal judgment required of inspectors. Again in theory, this operates to eliminate the judgment of the inspector on the problem of fact finding. This is not to say that when the facts are known the inspector still faces, in all cases, an important problem of judgment. On the contrary, knowledge of the facts in the vast majority of cases yields automatic judgments, and we shall dwell little on these.

In an elementary case, where the specification reads, "Diameter 0.500 ± 0.002," the inspector

(*a*) Measures the diameter with a micrometer and finds it to be for example, 0.4987

(*b*) Compares this 0.4987 with the limits and finds that 0.4987 is within the law.

A 0.498-0.502 ring gage will accomplish all of this high-sounding procedure in one swift simple operation. If the part enters the "go" ring but fails to enter the "no-go" ring, that is all there is to it. Neither does the micrometer measurement of 0.4987 present any problem to speak of in the presence of specified limits of 0.500 ± 0.002.

Nevertheless, there do exist real problems of judgment even when the facts of specification and product are both crystal-clear. Two of the most important cases are:

1 The product is clearly outside of specification but can be used.

2 The product is borderline in character.

ACCEPTANCE OF MATERIAL NOT CONFORMING WITH FUNCTIONAL LIMITS

It should be an inflexible rule that the inspector may not accept product deviating from functional limits without first obtaining the approval of the product-design engineer. This rule is fundamental, yet in some shops it is disregarded at times. The disregard arises not from any feeling that the functional limits are unimportant or capricious. Rather it arises from the inspector's opinion that the cost of repairing or junking the pieces in question is much greater than the loss of usefulness if the defects are accepted for use. Yet, even if the inspector's opinion is entirely correct, it is an unhappy type of discipline to permit the inspector to revise the functional design of the product, so to speak, even for one batch. The inspection force should be trained to understand that acceptance of material deviating from functional limits is no more their duty than is the audit of the company's books.

There are various reasons for this strict view. The product designer who is designing product B (which is intended to function with product A in the field) is entitled to assume that the functional limits on the earlier product A were met at the time product A was produced. Furthermore, a year hence, the designer may design product C to function with both products A and B, and he has a right to rely on the functional limits for products A and B having been met.

In many cases, the reasons for the existence of a functional limit arise from some feature of field performance not encountered in the shop. It is all too easy for the shop to jump to erroneous conclusions in such instances.

Finally, it is too severe a breach of functional authority for the inspector to change the functional limits of the product. The precedent of clear cases can all too easily give rise to cases which are clear to the inspector on the facts as he has them, but he may not have all the facts.

Notwithstanding the foregoing, there should be a way for the inspector to approach the designer with specific problems and to obtain the designer's approval for accepting such material if this be the right thing to do. There are many instances which can bring this necessity about. An expensive tool may have been made up, failing to meet a functional limit dimension; the specified raw material may be unobtainable, and the substitute material available may fail to meet one or more of the functional limits; an important shop blunder may have affected a large mass of product. The list is long and varied.

The usual channel provided for the inspector to approach the designer is through the manufacturing planning engineers, whose drawings carry both the functional and the manufacturing limits. In many cases the inspector may not be able, from the drawing alone, to judge whether the limit is functional or manufacturing in nature, and must obtain such information from the planning engineer. Another channel frequently used for going to the design engineer is through the check inspection department.

A further question arises as to the nature of the authorization to be given by the designer in the event he agrees to accepting the product in question. Frequently it is sufficient for the designer to issue a letter or memorandum covering the facts. Where, as in the case of the expensive tool, the designer is

[1] This paper is derived from chapter 4, "Conformance," of the author's forthcoming book, "Practical Inspection and Quality Control."

satisfied to let the temporary waiver become a permanent change in design, a change in drawings becomes warranted.

ACCEPTANCE OF MATERIAL NOT CONFORMING WITH MANUFACTURING LIMITS

The manufacturing limits are intended primarily to specify a means for economical and effective manufacture. There are many methods of making the product to meet the functional limits, some of these methods being more economical than others. The manufacturing limits are a means to the end—not an end in themselves. Accordingly, in case of failure to meet a manufacturing limit, it may be feasible to salvage what would otherwise be an expensive repair or junk bill without any effect on the functional limits.

Consider, for example, a case of ordinary machine screws which are five per cent slightly oversize on the outside diameter. As a practical matter, such screws will assemble satisfactorily with standard nuts except nuts at the minimum root diameter. If there are five per cent of the nuts at minimum dimensions, only $1/20 \times 1/20$, or 1/400, or $^1/_4$ per cent of the assemblies will give an interference. In some cases it may be cheaper to absorb this condition in assembly than to sort or to junk the screws.

It is a very close question as to whether the inspection department should have authority to accept such deviations on its own responsibility, or whether it should be required to obtain the prior approval of the engineer who specified the limits. There is no unanimity on this question. In the author's judgment the inspection department should have the authority to take such action on their own responsibility (always excepting deviations from functional limits). However, a prudent inspector will get the advice of the engineer in other than open and shut cases. In very close cases, the inspector may well ask the engineer for a written concurrence.

The acceptance of such defective work should be done in a way which will still subject the operator and shop foreman to a rejection. Unless this is done, the inspector loses face in the eyes of an operator who has produced defective work. The operator will contend to himself that he knew all along the parts were good enough and that the "delayed acceptance" by the inspector vindicates him (the operator). The operator should be treated on the basis that the work has been rejected and that the subsequent acceptance was a salvage undertaking in which, by good fortune and quite independent of the efforts of the operator, the parts were salvageable.

ACCEPTANCE OF CONDITIONS OF POOR WORKMANSHIP

No area of the Quality Law gives the inspector as much daily grief as does the Law of Good Workmanship. It is the problem of maintaining order when there is no written statute on the subject, just as the patrolman on the beat faces his most irritating tasks on those matters not specifically covered by ordinance.

The inspector is invariably accused of making up his own rules on this subject. To a large extent this is true, for the effectiveness of any attempt to define good workmanship in the specification is dwarfed by the importance of the inspector's interpretation. Specification or not, it is the inspector who decides what constitutes good workmanship.

Furthermore, the inspector is frequently forced to fight the battle of good workmanship single-handed. In the case of failure to meet functional limits and manufacturing limits, the engineers are the allies of the inspector in maintaining the sanctity of the limits. But the engineers are usually careful to avoid being embroiled in problems of shop workmanship.

A further complication of this problem is present in piecework shops. Here the operator may contend that he has fully met the terms of the piece-rate instructions and that the inspector is demanding a workmanship which was not envisioned by the piece-rate setter when the rate was established.

A case commonly encountered is that in which the pieces produced are perfectly usable but deviate from a "nonessential" dimension by an amount greater than is considered good workmanship in the "shop standards" for the operation. For example, a batch of adjustable leather carrying straps was cut one half inch longer than specified, after which the exposed cut end had been metal-tipped. The inspector took the stand that the operator should cut off the excess, and retip. The inspection supervisor very properly accepted the batch, but made a point of showing the condition to the shop foreman. To have accepted the condition without bringing it to notice would have been a breach of quality discipline.

On the whole, the absence of written measurable limits forces the inspector to be discreet about enforcing good workmanship. One inspection supervisor known to the author had a good method for keeping workmanship at a high level. He regularly instructed his inspectors to make summary rejections of all cases of poor workmanship. When the cases were appealed to him, he would, in many cases, overrule the inspector on the basis of "this lot, but no more after this lot." In this way the operators and the inspectors both saved face, the operators were put on notice, and the amount of poor workmanship accepted was kept at a minimum.

BORDERLINE PRODUCT

The case of the borderline product has two aspects:

1 The individual pieces are very close to the specified limits. Some gages will measure the parts as "O.K." and other gages as "not O.K." The human error of reading scales, normally too small to give trouble, may be enough to swing the decision when the product is very close to the line.

2 In sampling inspection the percentage of defective pieces may be very close to the limiting per cent defective. In such event the accident of probability theory will show some samples with too many defects and other samples as good enough.

The basic policy followed in disposing of borderline product is of much more import than the disposition of the lots of product specifically involved. The policy also regulates the frequency and intensity of the border fighting between operators and inspectors. In addition, the policy strongly influences the entire state of quality-mindedness of the organization.

Most shops, unconsciously or deliberately, have a rule that the product is to be accepted unless the inspector can specifically point out why it should not be accepted. The inspector must demonstrate in what way the product fails to meet the specified limits. This is a just rule. The shop is presumed to be trying to make good product, not poor product. The inspector, like any other judge, should have to give reason rather than whim for his action.

This practice has the effect of putting the burden of proof on the inspector. Somehow it seems to be human nature to ask for such proof beyond a reasonable doubt. (We may have learned this from the legal profession.) Whatever the origin, this principle of proof beyond a reasonable doubt is carried on high by the operators, the shop foremen, the expediters (to whom the inspector is just another hurdle in the way of getting out production), and all others involved.

From the very nature of things, borderline product is not defective beyond a reasonable doubt. The shop foremen are quite sincere in their urging that such product be accepted without further ado. Notwithstanding all this, the inspection department which makes a standard practice of accepting borderline material is heading itself, and the rest of the shop as well, into a habit from which the price of exit can be very high.

In the first place, the acceptance of borderline material creates a precedent which cannot be broken without accusations of discrimination or favoritism. If the diameter is specified at 0.500 ± 0.002 and the inspector accepts a batch from operator *A* including a percentage of pieces which meas-

ure 0.5022, the inspector cannot very well reject a similar condition on operator *B*.

Second, the acceptance of borderline material tends to break down the entire discipline of meeting the limits. If a batch measuring 0.5022 is accepted today from operator *A*, he will expect similar treatment a week from today. This will result in his considering that 0.5022, and not 0.5020 is the maximum. The inspector thus induced an unwritten change in specification, and certainly an unauthorized change.

In the third place, factory operators possess the basic human desire for more and more freedom. Such being the case, they will not stop at 0.5022, the new unofficial specification limit. They will urge acceptance of material measuring 0.5024 on the theory that it is only 0.0002 out of (the new) limits. This logic is identical with that advanced when the product was 0.5022 and the limit 0.5020.

The ideal answer to all this consists of generating a concept of quality-mindedness in the operating forces to such an extent that they will bend every effort to avoid making borderline material in the first place. In the absence of such a concept, the inspector must use the only real weapon at his disposal. He must make the acceptance of borderline material so difficult and so involved as to discourage even the hardiest souls from going through the process again. This may include getting precise laboratory measurements on the product before taking action at all. Upon these precise measurements showing the product outside of limits, however small the deviation, a formal rejection should be made, to put the burden of appeal on the foreman. Upon appeal, the inspection supervisor should take the view that he will not accept these defective pieces, and that if the chief inspector orders them accepted, that is the chief inspector's decision.

These and other means of making it difficult to get borderline material accepted will achieve the effect, by a sort of brute force, it is true, of maintaining a quality discipline. This discipline is fully as important as military discipline. A soldier without a shave can fight as well as a soldier who is shaved. Yet relax these small disciplinary rules, and seams develop in the whole system.

It need not be supposed that this stern method of dealing with borderline product need result in the junking of much valuable material. (In passing we can note that a limited amount of this would be a cheap price to pay for real quality discipline.) Frequently the material is repairable. Where it is not repairable and would, if junked, be a serious loss, it is still good business to require the foreman to make out a junking ticket and to go through all the motions of junking the material, after which consideration can be given as to whether the product will be accepted as a salvage project. There need be no hesitancy in considering the acceptance of usable borderline product once the operator and foreman who produced it have had to swallow a rejection and have had to go through the motions of junking it, with the resultant loss charged up to the department record.

CONFLICTING MEASUREMENTS

Where the product is nonrigid, measurements by gages are greatly influenced by the pressure exerted and by the position at which the reading is taken. It is good practice when measuring rubber, leather, textiles, paper, and similar materials for thickness to use broad-anvil micrometers and to specify the pressure to be exerted by the jaws at the time of taking the reading. Measurements can be taken at identical positions on the sample if the sample is marked or masked in a way which clearly points to the spot measured.

In inspection of purchased materials the problem of conflicting measurements is difficult to resolve because the plants may be widely separated geographically. It is good practice in such cases to exchange specimens, these being carefully identified as to piece and position so that any difference in readings taken will reflect only the difference in gages and gaging practice rather than any differences existing between specimens, or within the same specimen.

In some tests, such as Rockwell hardness, tensile strength, and the like, successive tests will vary one from another in much greater proportion than do successive measurement of such features as linear dimensions on rigid bodies. The result is that the border line becomes a broad band which occupies a sizable segment of the scale of measurement. Specifications for such tests must recognize the measurement problems involved if the requirements are to be realistic.

To be more specific, assume a tensile strength requirement of 30,000 pounds per square inch minimum. Does this mean:

(*a*) That each piece tested of those tested should yield a reading of at least 30,000 when tested;
(*b*) That the average of the pieces tested should be at least 30,000;
(*c*) That if a thousand pieces be tested each should read at least 30,000?

The more the pieces tested, the greater the likelihood of finding one or more pieces measuring below the minimum. Accordingly, in such cases, if the specification fails to be precise as to number of pieces to test, or as to the percentage of pieces which must meet the test, there is a possibility that readings will conflict and will produce a deadlock difficult to resolve. This may be particularly difficult in the case of materials purchased from some independent company, for in such event there is no supervisor common to the two organizations.

CONFLICTING INTERPRETATIONS ON NON-NUMERICAL INSPECTION ITEMS

If an inspector is given a pile of punched pieces to sort for excessive burrs and is later given the identical parts to sort a second time for excessive burrs, he will not, on the second sorting, exercise judgments identical with those made on the first sorting. There are many reasons which account for this, but the fact remains. If the inspector himself cannot exactly repeat his own judgments, he will assuredly not obtain results identical with those obtained by the operators. In some parts of the shop, such differences on non-numerical inspection items may be a source of constant irritation to the people involved.

In one department where there was much designation stamping to be done, the problem of what constituted crooked stamping was solved when the inspection supervisor and the operating foreman jointly appointed an inspector in whom all had confidence to be the umpire for all borderline cases of crooked stamping. There was no appeal from his decisions. He was justly proud of his distinction and was careful to keep his judgment balanced lest he lose the prestige of being umpire.

A more usual device is the "up-the-line" appeal in which the supervisors jointly look over the questionable material to make a settlement. If in such cases the end result is merely disposition, one way or another, of the questionable batch of product, the way is open for like questions to be raised in the future. The supervisors can make a contribution by explaining to the people on the job the basis of the decision. It may be feasible to set up samples or standards to guide the shop in future instances. Such contributions go to make up the shop standards.

DIVISION OF RESPONSIBILITY BETWEEN INSPECTOR AND SUPERVISOR

Throughout the foregoing we have referred to the "inspector" as the person judging conformance. It would be more accurate in this connection to use "inspector" in its generic sense as meaning anyone exercising the authority of the inspection function, up to and including the chief inspector.

In most shops, as a practical matter, the inspector "at the bench" has no authority to reject or to accept anything. The authority to make disposition of product is reserved to the

inspection supervisor. Thus, when the inspector has found defective or questionable pieces (and also in cases where he has found no defectives), he brings these facts to his supervisor, and not to the operator or shop foreman. The inspection supervisor then makes the final judgment as to conformance, and the inspector acts accordingly.

It is desirable to avoid subjecting the bench inspector to any direct dealings with high-ranking supervisors on whom a rejection might fall. Furthermore, it is well to bring the inspection supervisors into all cases of trouble to provide greater assurance that the cause of the defective work will be traced down. Under this arrangement the function of the inspector is one of fact finding, plus preliminary judgment, or recommendation, as to disposition of the product. The inspection supervisor makes the final judgment. This is a very satisfactory arrangement, for it keeps the inspection supervisor advised of what is going on and at a minimum of supervisory time. In some cases the supervisor may designate some experienced inspector to investigate cases of trouble and to report back to him, but he still reserves the right of decision as to conformance of product.

In the ordinary course of events, the inspection supervisor makes an on-the-spot decision for the inspector who then accepts or rejects the product as instructed. In close cases, where the advice of higher supervisors, engineers, and others may be required, it sometimes happens that the inspector is never told what was the final outcome. To fail to inform the inspector in such cases is to fail to give him training on those cases which are the most instructive. The inspector learns little from an open-and-shut case. He can learn much from the close cases, and supervisors should be on the alert to inform inspectors of the decisions in such cases, *including the reasons for the decisions*.

REJECTIONS

The human relations which arise in the course of a rejection of manufactured product make an interesting problem for psychological analysis. Certainly the inspector undergoes some sort of exhilaration—the satisfaction of a job well done—the relief over having avoided whatever would befall *him* if he had failed to find the defects—possibly there may be some sort of satisfaction in having prevented the operator from "putting something over."

On the operator's side of the story, there is the shock of realization that some sort of supervisory censure is to be forthcoming. There may be chagrin if there really was an effort to "put something over." There may be loss of pay under the payment system. There may be a demerit in the unwritten score which regulates promotion. In group pay systems there may be the team-mates' reaction to the player who has dropped the ball.

Aside from all this, which is undoubtedly incomplete, the supervisors involved also are subjected to various pressures, depending on the seriousness of the case. Quite by chance a rejection may create a bottleneck in production because the batch in question may be badly needed in a succeeding operation. In such event the incident may come to the attention of the plant manager. Yet had the inventory of such parts (by chance) been fat rather than lean, the rejection might have created no fuss at all.

In such settings it behooves the inspection supervisor to make his rejection on a factual, dispassionate basis. It is not for him to censure the operators or the foremen. It is not for him to comment on what must have been the mentality of those who produced such defects. It is not for him to give out any information concerning the rejection to any save those authorized to receive reports on such matters. All this is important. The operators resent gossip about their shortcomings. They resent "rubbing it in" even more. The chief inspector will do well to discuss with the inspection supervisors, from time to time, the code of ethics to follow in making rejections.

Cases arise in which the product meets the specification limits but in which the specification itself turns out to be wrong. In such event the greatest care should be taken to avoid any semblance of criticism of the operating force when making a rejection.

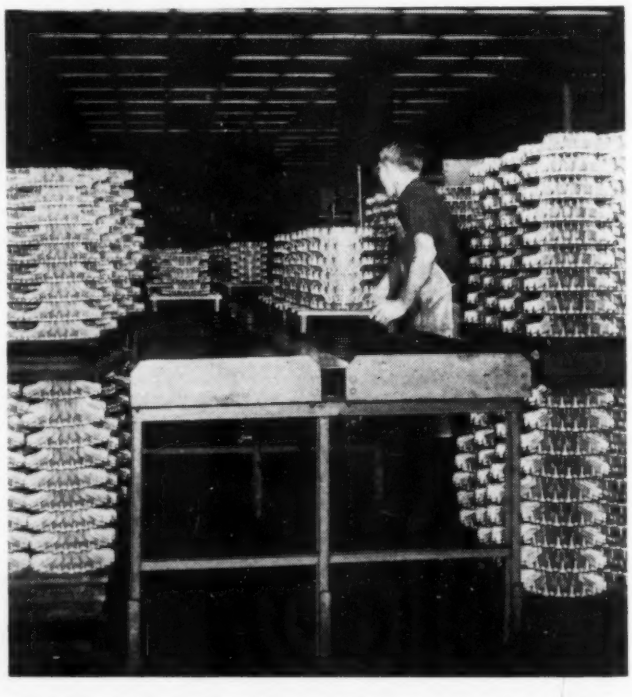
In many shops the inspection department has important responsibilities in tracing defects in their source. In such event a rejection should always be constructive—it should be accompanied with a maximum of facts and suggestions for avoiding repetition.

SUMMARY

Judging manufactured product for conformance with the quality specification puts on the inspection force all of the responsibilities which go with the exercise of a judicial function. A clear understanding of the facts, a clear understanding of the quality law, and a lack of bias are all fundamental to this undertaking. This judicial act often leaves to the inspector a broad band of individual discretion.

The inspector has no authority to accept material outside of the functional design limits, though he may find the designer willing to make temporary or permanent waivers in special instances. In the case of the manufacturing design limits and good-workmanship limits, the inspector should have authority to make waivers. He should, however, be humble about asking the advice of the engineers on such matters.

Products at the border line of acceptability and products which yield conflicting measurements present the inspector with difficult decisions in judgment of conformance. The fact that the disposition of the product impinges heavily on other members of the industrial world in which the inspector lives—the engineer, the shop foreman, the plant manager, and others—adds to this difficulty. The inspector's judgment is subject to challenge and review. There may be honest differences of opinion and there may be differences arising from the varying interests of the people involved. It is an atmosphere requiring the highest degree of integrity, of tact, and of human understanding to keep relations harmonious.



HUNDREDS OF SUPERCHARGER IMPELLERS ON PALLETS AT GENERAL ELECTRIC PLANT

NATURAL FATS *as* LUBRICANTS

Some Lubricating Characteristics of Natural Fats Under Conditions of Non-Fluid Friction

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NATURAL fats have long played an important role in the formulation and manufacture of industrial and metal fabrication lubricants. While it is well recognized that the lubricating characteristics of petroleum oils and many other liquids can often be considerably improved by the addition of various natural fats, and long-chain polar molecules in general, there is as yet no agreement as to the manner in which these additives function. Also, there appears to be a general tradition among those to whom the problems of industrial and metal fabrication lubrication are of immediate concern, that each natural fat, or modifications and combinations thereof, possesses unique lubricating characteristics with reference to a given application which cannot be readily duplicated by other natural fats or natural-fat blends. A typical example is that of the widespread use of palm oil as a rolling-lubricant component in steel-rolling operations. Thus, while natural fats are the oldest lubricants known to man, knowledge regarding the fundamental factors controlling their characteristics as lubricants is still in a relatively undeveloped state.

The classic work of Hardy and Doubleday (1)[1] provided the first fundamental experimental and theoretical approach to the general problem of the role played by polar molecules when functioning as lubricants or as lubricant additives. Briefly, Hardy showed that the lubricating characteristics of long-chain polar compounds vary in direct proportion to the molecular weight (chain length) and to the "polarity" of the molecules. The physical picture advanced by Hardy was that the polar molecules become preferentially adsorbed at, and oriented perpendicularly to, the metal lubricant interface, with the polar groups attached to the metal surface and the hydrocarbon radicals extending away from the metal surface. On that basis, adhesion and chain length of the polar molecules are the determining factors in controlling the "oiliness" phenomena.

Hardy's theory was well received and widely used. However, other authors (2, 3) have since obtained evidence which has aroused some doubt as to the validity of Hardy's theory, or at least suggests the co-existence of important modifying variables.

A major point of contention in the problem of fundamental lubricant studies centers around the various types of apparatus employed in studies of the relative effects of the many variables associated with the performance of lubricants in given applications. In view of the time, expense, interference with production, and unsatisfactory control of variables involved in field or plant-scale investigations, satisfactory methods for the evaluation of the lubricating characteristics of a given lubricant on a laboratory scale are urgently needed. Of the many ingenious units of apparatus designed in an effort to meet this need, at least five are now commercially available in this country. They include the Falex (Faville-LeVally or Cornell machine); Timken apparatus; S.A.E. machine; Almen machine; and Shell 4-Ball apparatus. The value of such apparatus in conducting fundamental and practical research has, unfortunately, been open to considerable question because of the fact that the rating of a series of oils, for example, often varies with the particular apparatus used and in many cases does not appear to correlate with known field-performance characteristics.

While a discussion of the many aspects of this interesting and important problem is beyond the scope of this paper, it is felt that it would be of interest to point out that extensive studies carried out in the Aluminum Research Laboratories, supplemented by carefully controlled tests on full-scale-plant production equipment, indicate that such apparatus can be utilized to give laboratory data which correlate well with actual field-performance characteristics. The author is of the opinion that the various types of lubricant-testing apparatus have been undeservedly criticized for apparent discrepancies in results which are due primarily to the general ignorance regarding lubrication variables rather than to "misdemeanors" on the part of the lubricant-testing machines.

PURPOSE AND CONDITIONS OF TESTS

The primary purpose of this present investigation was that of obtaining a preliminary evaluation of some of the relative lubricating characteristics of representative natural fats, as determined by the described experimental procedure.

The data reported in this paper were obtained using the Falex (Faville-LeVally) lubricant-testing machine. In that machine, two V-shaped steel test bearing surfaces are pressed against a rotating steel pin. Both the V-shaped and the pin test bearing surfaces are immersed in an oil cup. Torque and applied-load values are indicated by two gages. The applied loads can be varied automatically or at will, although only two rubbing speeds are available. For the purpose of the present investigation it was assumed that high load-bearing capacities (as indicated by large values of applied loads at failure) and low torque values represent desirable lubricating characteristics.

Experimental Procedure. Standard steel test journals and blocks, as supplied by the Faville-LeVally Corporation, were employed in all tests. These were cleaned prior to use by soaking in benzene for several hours, and the surfaces were well wiped with clean cheesecloth before use. A series of preliminary experiments indicated that various test-piece bearing-surface cleaning treatments had little effect upon the results under the particular procedure employed. The major fluctuations in results were found to correlate with the different lots of test-piece shipments (see discussion of results) to a much greater degree than with the particular methods employed in cleaning the test pieces prior to use. The oil cup and the parts of the Falex apparatus in contact with the oil samples were thoroughly cleaned with several portions of solvent naphtha and dried after each separate run. The test pieces were then assembled, the oil cup placed in position, and the run started.

The runs were carried out by adjusting the 4000-lb Falex load gage to the point where any additional tightening of the loading wheel would produce the first perceptible movement of the load-indicator hand. The machine was then started, the loading ratchet engaged, and the load run up to a gage value of 500 lb. The loading mechanism was then disengaged and the

Contributed by the Special Research Committee on Lubrication of The American Society of Mechanical Engineers.

[1] Numbers in parentheses refer to the Bibliography at the end of the paper.

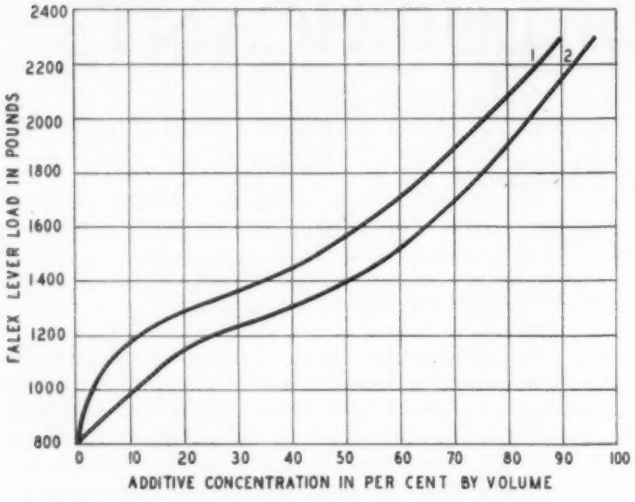

FIG. 1 FALEX FAILURE LOAD VERSUS ADDITIVE CONCENTRATION
(Additive: 1 Cottonseed oil. 2 Palm oil.)

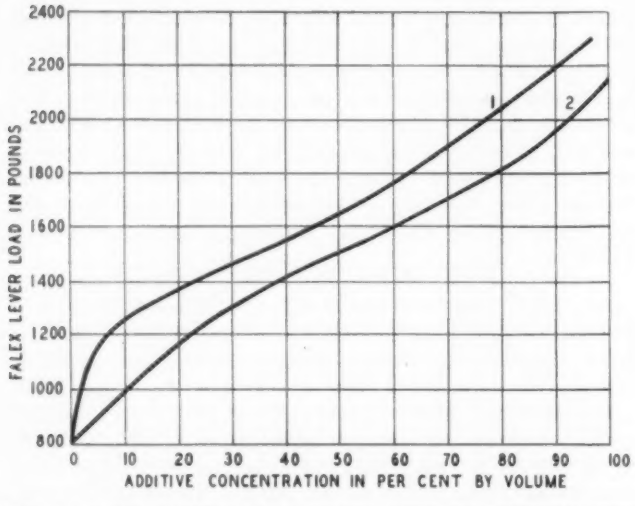

FIG. 2 FALEX FAILURE LOAD VERSUS ADDITIVE CONCENTRATION
(Additive: 1 White mutton tallow. 2 No. 1 lard oil.)

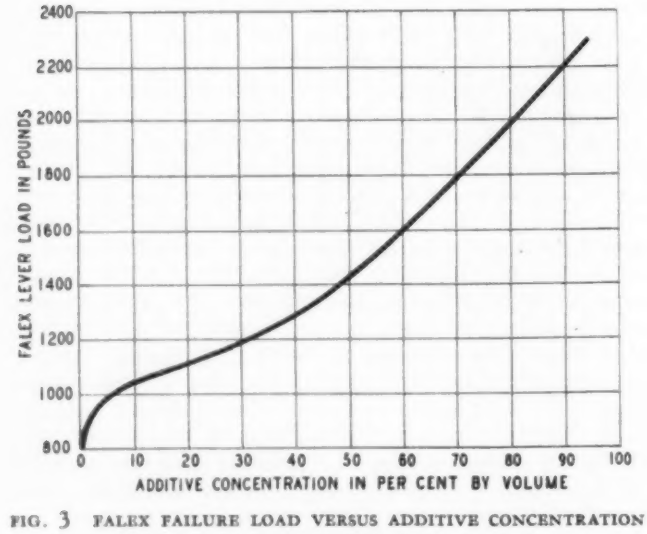

FIG. 3 FALEX FAILURE LOAD VERSUS ADDITIVE CONCENTRATION
(Additive: Winter-pressed Menhaden fish oil.)

machine allowed to operate for five minutes. Several torque values were recorded during the five-minute run-in period, after which the loading mechanism was again engaged. The applied load was allowed to increase until failure was obtained, the torque values being recorded at each 250-lb lever load increment.

A well-refined mineral oil (500 S.S.U at 100 F) was employed as the vehicle oil. The natural fats employed are representative of the commercially available grades.

Results. The Falex failure-load values obtained with 5 per cent (by volume) concentrations of 13 different natural fats are given in Table 1. These results indicate that, in general, there

TABLE 1 FAILURE-LOAD VALUES OF REPRESENTATIVE ANIMAL-VEGETABLE-MARINE NATURAL FATS IN CONCENTRATIONS OF 5 PER CENT BY VOLUME[a]

Natural-fat additive	Failure load in Falex lever-load gage, lb
Palm oil	900
Coconut oil	1060
Peanut oil	1020
Rapeseed oil	920
Cottonseed oil	1100
Lard oil	900
White mutton tallow (edible)	1180
Beeswax	1050
Menhaden fish oil (winter-pressed)	1000
Hydrofol (marine)	1000
Hardened cosmol (hydrogenated marine)	1100
Hydrofol glycerides (marine)	900
Sperm oil (winter bleached)	1000
Circo medium-heavy mineral oil (no additive)	800

[a] Vehicle oil: Circo medium-heavy mineral oil (500 S.S.U. at 100 F).

is little difference among the various natural fats on the basis of failure-load values.

The dependence of Falex load values upon additive concentration for two vegetable fats, one marine fat, and two animal fats are shown in Figs. 1, 2, and 3. These indicate a definite increase in Falex load values with increasing concentration of natural-fat additive. Also, it is of interest to note that the general type of curve obtained is the same whether the fat be of animal, vegetable, or marine origin.

The relationships existing between the additive-concentra-

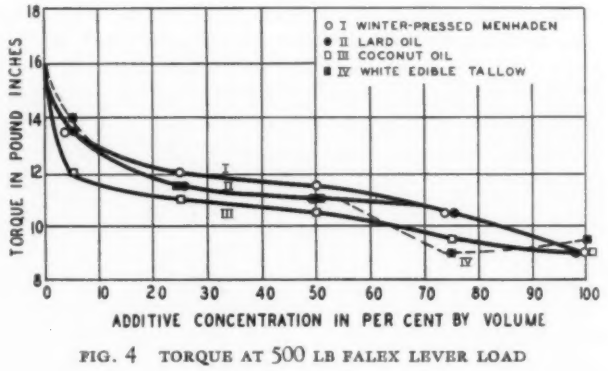

FIG. 4 TORQUE AT 500 LB FALEX LEVER LOAD

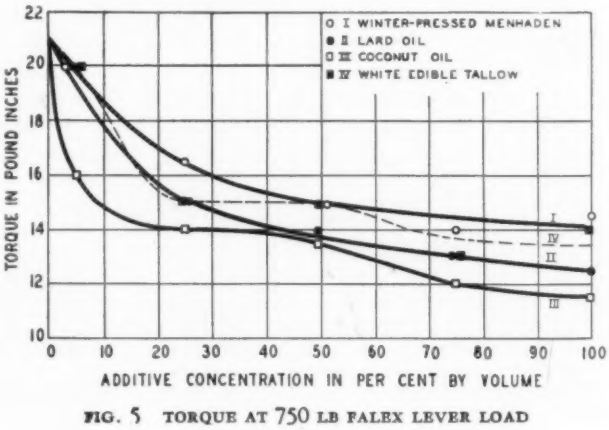

FIG. 5 TORQUE AT 750 LB FALEX LEVER LOAD

TABLE 2 TORQUE VERSUS FALEX LEVER LOAD FOR 75 PER CENT CONCENTRATIONS OF TYPICAL ANIMAL, VEGETABLE, AND MARINE FATS IN MINERAL OIL

Additive	Torque, lb-in., at Falex lever load					
	500	750	1000	1250	1500	1750
Palm oil.....	8.0	12.0	16.0	20.0	24.0	34.0
Mutton tallow.....	9.0	13.0	18.0	22.0	25.0	28.0
Menhaden fish oil..	10.5	14.0	21.5	25.0	34.0	40.0

tion variable and the resultant torque values (Falex torque values are directly proportional to frictional resistance) at Falex gage-load values of 500 and 750 lb, are shown in Figs. 4 and 5. Here again, there is a general decrease in frictional resistance with increasing concentration of additive as indicated by the torque values.

The dependence of torque values upon load values is shown in Table 2 for 75 per cent concentrations of typical animal, vegetable, and marine fats in mineral-oil solutions. This concentration was selected as a typical example, and also because it is the point at which the majority of the torque values reach their lowest readings.

DISCUSSION OF RESULTS

All of the reported values are average values of at least eight duplicate runs. In order to avoid variations in results arising from the use of different lots of test pieces, test pieces taken from various lots were thoroughly mixed into a single lot, and the test pieces used were then selected from this mixed lot. In this way it was found that average failure-load and torque values, taken from various sets of duplicate determinations, could be consistently duplicated to within better than 10 per cent.

Any attempt at an interpretation of the results obtained relative to the load-bearing and frictional characteristics of the natural fats on the basis of chemical structure is complicated by the fact that the natural fats are mixtures of several different chemical constituents. Thus, a typical natural fat is likely to contain the mono-, di-, and trifatty-acid esters of glycerine, free saturated and unsaturated fatty acids of various molecular weights, free alcohols, monohydric-alcohol, fatty-acid esters, etc.

In general, however, the bulk of the natural-fat constituents will be primarily characterized by the glycerides of normal alkyl fatty acids, ranging in chain length from the C_8 to the C_{22} acids, with greater or lesser amounts of free fatty acids falling in the same molecular-weight range. Thus natural fats will differ from each other primarily in the average chain lengths of the constituent fatty acids and their polyhydric-alcohol esters; in the ester-free acid ratios; and in the relative degree of unsaturation. If the assumption is made that the variations in those variables from natural fat to natural fat will in general be mutually compensating with regard to resultant lubricating properties, then, in so far as the intrinsic physical lubricating characteristics of natural fats are concerned, these might be expected to be reasonably equivalent regardless of the particular natural fat.

Beeck and co-workers (4) offer an interesting physical picture of the manner in which long-chain polar molecules perform their lubricating functions. On this basis, the adsorbed oriented polar molecules which are firmly attached to the metal-oil interface exert a definite physical "wedging" effect, tending to prevent metal-to-metal contact. This wedging effect is a function, among other things, of rubbing speed and of the polar-molecule structure. Kyropoulos (6), however, states that the chain length and structure of the polar molecules are relatively unimportant, the primary variable being that of chemical reactions between the adsorbed molecules and the bearing surfaces, or the effect of the adsorbed polar molecules upon the metal-oil-dissolved gases reactions.

The physical basis offered by Beeck (4), coupled with the molecular-regimentation theory of Sterrett, Clark, and Lincoln (5), provides a satisfactory explanation for the observed relationships between the torque and load-bearing capacities of the natural fats and their concentrations in the mineral-oil solutions, particularly when, in any given operating case, the modifying "Reynolds wedge" effect associated with the viscosity characteristics of the lubricant is taken into consideration.

With respect to effects of natural-fat additions upon the frictional characteristics of a nonpolar mineral oil, it is interesting to note that, at moderate bearing loads (Figs. 4 and 5), 5 per cent additions lower the torque values by approximately one half of the maximum possible net effect obtainable with the straight natural fat. With increasing bearing loads, however, the 5 per cent additions become less effective.

CONCLUSION

With the possible exception of certain chemical considerations, such as oxidation stability, oil solubility, surface-tension characteristics, etc. it appears that no single natural fat possesses physical lubricating characteristics which are the unique property of the particular natural fat. It should therefore be possible to surmount many difficulties caused by the present war-created shortage of imported and certain domestic natural fats where these are employed either as industrial or metal fabrication lubricant constituents, by an intelligent and increased application of the more abundant natural fats and their derivatives.

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Care of Cooling Systems

OPERATORS of motor vehicles and of any kind of equipment in which liquid-cooled engines are used can save themselves a lot of trouble and expense by faithful attention to the information and recommendations in a 34-page pamphlet issued by the Office of Defense Transportation under the title "Cooling System: Cleaning, Flushing, Rust Prevention, Antifreeze."

In simple terms and with many illustrations, the seven sections of the pamphlet give detailed instruction on checks and tests for cooling liquid losses; on routine maintenance of the cooling system; on finding the causes of overheating and overcooling; on causes of corrosion and on the prevention of rusting; on factors leading to clogging of the cooling system and ways to prevent it; and on the characteristics of different types of antifreeze and their use.

The pamphlet is the latest in an automotive maintenance series prepared by the Society of Automotive Engineers and issued by the Office of Defense Transportation. Any of the series may be obtained from the Office of Defense Transportation, 1147 New Post Office Building, Washington, D. C., any of the 142 district offices of the ODT Division of Motor Transport, or regional offices of the ODT Office of Information.

GOVERNMENTAL ADJUSTMENT *of* LABOR DISPUTES[1]

By W. RUPERT MACLAURIN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY CAMBRIDGE, MASS.

THIS new book[2] by Howard Kaltenborn, chief analyst of the War Labor Board of Detroit, is a very timely discussion of an important subject. Professor Witte has written a foreword in which he describes Mr. Kaltenborn as one of his former students of whom he is most proud. As a professor at the University of Wisconsin, Dr. Witte has had a great many outstanding students under him at one time or another, so that these words are high praise.

Dr. Witte states in his foreword that he has become convinced that there is no way compatible with democracy in which strikes can be eliminated. He is also convinced that it is the duty of government to make available the most effective possible machinery for an amicable adjustment of labor disputes. No country, he writes, has found a method of preventing strikes. Australia, after many years of experience with compulsory arbitration, seems to have more strikes in proportion to its industrial population than any other country. In World War I, England prohibited strikes by criminal penalties, but it had far more strikes than in peacetime. In the present war, England's record has been the best of any of the Allied nations, but some strikes have occurred in every month, even when the bombings of the Luftwaffe were at their height. In the enemy countries strikes are suppressed with great brutality, although the Nazis have never prohibited strikes by law or decree. Yet strikes have occurred in Germany itself and have caused no end of trouble in the occupied countries.

In the United States we are at this time introducing more compulsion in labor relations than we have ever had before. It is quite clear that after the war the government will continue to serve in an important capacity in the prevention and settlement of labor disputes. Therefore, the present up-to-date account of the legislation and experience with mediation in this country should be of great value.

U. S. CONCILIATION SERVICE

Under the stimulus of this introduction, Mr. Kaltenborn discusses the experience of the major agencies in the United States concerned with labor disputes and attempts to appraise their effectiveness. After a historical résumé, he describes the role of the United States Conciliation Service, which is the largest mediation service in the United States, and which has done valuable work in adjusting labor disputes, particularly in the last six or seven years. While he finds the Conciliation Service to have been, in general, a successful mediation agency, certain defects in its structure seem apparent:

(1) The Conciliation Service is a division of the United States Department of Labor, and many employers believe that the Department is a partisan agency. Mr. Kaltenborn believes that the weight of the arguments pro and con supports the conclusion that the Conciliation Service should be taken out of the Department of Labor and made a separate agency and that the present single director of the Service should be replaced by a three-member board.

(2) The United States Conciliation Service should be given specific statutory authority and status, and Congress should enunciate a definite public policy for the guidance of the Service and of the disputing parties.

(3) It would probably be better if the Conciliation Service were organized along industrial rather than regional lines. It is virtually impossible for a commissioner who handles disputes in all types of industries to acquire a detailed technical knowledge of any one industry.

NATIONAL MEDIATION BOARD

Turning to other organizations for mediation, Mr. Kaltenborn concludes that the National Mediation Board, which has charge of disputes in the railroad and commercial-air-lines industries, is the best contemporary example of a successful mediation agency. Although the record of the National Mediation Board in averting stoppages is not quite as good as that of its predecessor, the United States Board of Mediation, the record of both boards in this respect is undeniably very good.

NATIONAL DEFENSE MEDIATION BOARD

The National Defense Mediation Board should not be confused with the National Mediation Board. The "Defense" Board was established by the President in March, 1941, to settle labor disputes in defense industries. After the resignation of the C.I.O. members of this Board in response to its recommendation in the "captive coal mines" case had seriously limited its effectiveness, President Roosevelt called the Labor Industry Conference in December, 1941, out of which arose the National War Labor Board. This agency, as we all know, has played a very important role in labor relations in the United States since its formation. The effectiveness of its work is a controversial issue and it is probably too early to assess the problem in its entirety. Mr. Kaltenborn does make an attempt to analyze the record of the War Labor Board and finds that in general it has been quite successful in disputes work. The number of strikes since Pearl Harbor has been substantially below normal and virtually all of these strikes have been of short duration. On the other hand, he points out that strikes will undoubtedly increase if the way to get prompt action on grievances is through striking; and this is apparently the purpose of the strikes now occurring. The War Labor Board is far behind in its docket, and if new cases are considered in the order in which they are docketed, a substantial delay will occur before a decision is rendered. However, as a case involving a strike must come to the attention of the Board very quickly, some way must be found to meet this problem.

NATIONAL WAR LABOR BOARD

An analysis of the dispute cases of the National War Labor Board shows that the Board was successful in adjusting by mediation only 25 per cent of the 330 dispute cases which are now closed. This is not as good a record as that of the National Defense Mediation Board, and considerably worse than the 80 to 90 per cent successful adjustments that are typical of most successful mediation agencies. The War Labor Board's somewhat inferior record, Mr. Kaltenborn believes, is due to three factors: (1) the difficulty of the cases which had already resisted mediation by the Conciliation Service; (2) the fact

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "Governmental Adjustment of Labor Disputes," by Howard S. Kaltenborn, Foundation Press, Chicago, Illinois, 1943, 327 pp.

that the members of the War Labor Board themselves did not engage in mediation; and (3) the flaws which Mr. Kaltenborn finds in the mediation procedure authorized by the Board.

The War Labor Board press releases reveal that the Board has been divided in many of its decisions. In the first year of operation, there were dissents in approximately one out of every three cases. Of course, divided decisions are not unnatural in view of the tripartite character of the Board. Most of the dissents by employers came on the issue of union security, while most of the dissents by labor concerned wage issues.

The Board made it clear from the beginning that its jurisdiction extends not only to disputes directly involving war production but also to disputes which might indirectly affect such production. Thus the Board took over the Montgomery Ward and Company case, even though the company maintained that it did not produce any war materials, that it had no government contracts, and that it did not distribute what could not readily be obtained by purchase elsewhere.

In discussing the major organization difficulties faced by the National War Labor Board, Mr. Kaltenborn concludes that, in general, mediation can be carried through more effectively by single impartial individuals than by a panel containing partial representatives. One of the major difficulties of the panel system was to hold the members of the panel long enough to get prompt recommendations. Usually the members were busy people who had to leave as soon as the hearings were concluded and the hearings often took longer than was expected. After the panel members had once returned to their homes, it was difficult to reassemble them or to get agreement by correspondence.

On this particular point, the reviewer can substantiate from his personal experience as chairman of a War Labor Board panel. The case concerned a company in Michigan and members of the panel came from Washington, New Jersey, and New Hampshire. Partly because of hotel and train reservations, all the panel members and the accompanying union representatives presenting the case were anxious to get away from Washington as quickly as possible. Before the case was finally settled, weeks of correspondence, telephoning, and telegraphing were necessary, much of which could have been avoided if the case could have been heard locally and in a more leisurely atmosphere. This situation has since been corrected by the War Labor Board's regional setup.

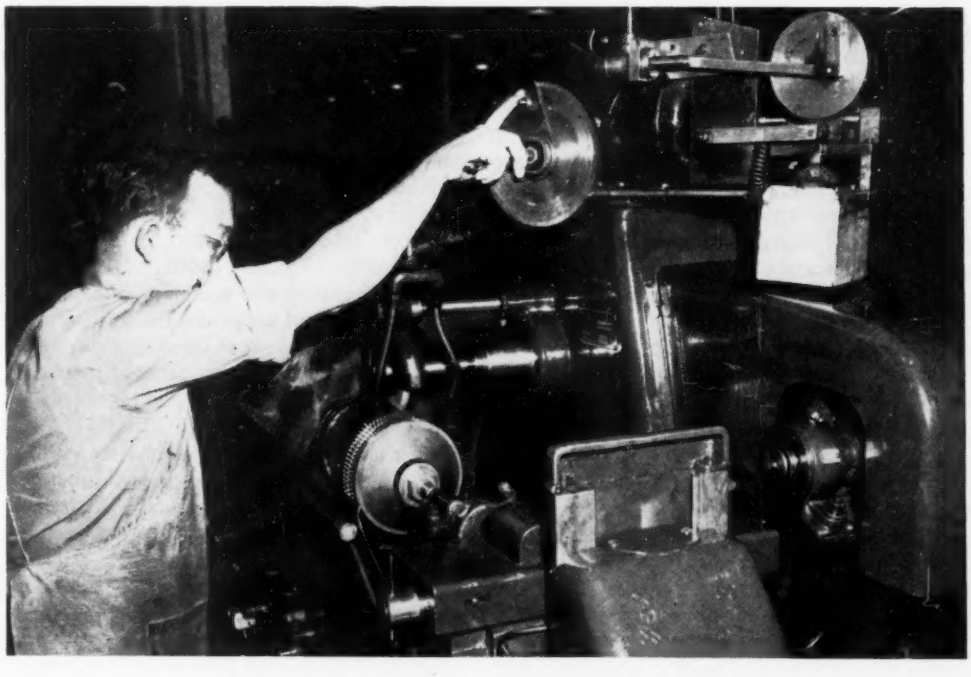
Mr. Kaltenborn says that since the establishment of regional offices the War Labor Board has been gradually building up its personnel, but the growth is not sufficient to cope with the inflow of cases. Moreover, it appears that the backlog is increasing.

One of the most difficult issues before the War Labor Board has been the problem of union security. In the past there has been a substantial controversy within the Board itself over this issue, but this controversy has temporarily abated. The War Labor Board has never required an employee to join a union. The maintenance of membership provision, which is generally prescribed by the Board, merely requires a person who has been a member to remain in good standing at least for the duration of the contract. The escape clause gives a union member a specific period of time in which he may withdraw from union membership; and the anticoercion clause protects the individual's right to withdraw.

In his final chapter Mr. Kaltenborn writes: "The total evidence, including that presented in the preceding chapters, clearly supports the conclusion that mediation is the best single method of governmental intervention in the adjustment of labor disputes." Past experiences with compulsory arbitration have not been too favorable. The reviewer personally agrees with this statement, from his experience based on a first-hand study made a number of years ago of the effect of compulsory arbitration in Australia.

Although it is not possible to summarize Mr. Kaltenborn's points on the technique of mediation, with recommendations applicable to the states and to the federal government on mediation legislation and procedure, they are well worth reading.

In general, Mr. Kaltenborn has made a very real contribution to an important and vital subject. He has covered a large amount of ground with care and impartiality and has presented his facts and conclusions in a systematic and effective way. In short, the book gives an up-to-date account of the legislation and experience with mediation which, as Dr. Witte states in his introduction, "has been badly needed for some time," and which should be "of great value to all people interested in this important subject."



AUTOMATIC INDEXER DEVELOPED AT LYCOMING DIVISION OF THE AVIATION CORPORATION FOR GEAR-TOOTH GRINDING OPERATIONS

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals and Events

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context and credit to original sources is given.

Salvaging the "Normandie"

MARINE ENGINEERING AND SHIPPING REVIEW

SALVAGE operations on the former French liner *Normandie*, transferred by the U. S. Maritime Commission to the Navy Department on Dec. 24, 1941, renamed the U.S.S. *Lafayette*, and damaged by fire at a New York pier on Feb. 2, 1942, are reported briefly in the September issue of *Marine Engineering and Shipping Review*.

It will be remembered that the *Lafayette* capsized and was resting on its port side at an angle of 79 deg. On Feb. 24, 1942, jurisdiction of the vessel was assumed by the Chief of the Bureau of Ships who placed it under the immediate cognizance of the Supervisor of Salvage, U.S.N.

In order to determine whether or not the *Lafayette* should be salvaged, the Secretary of the Navy, on April 15, 1942, appointed a special committee, J. Barstow Smull, J. H. Winchester and Company, Inc., New York, N. Y., chairman, to make recommendations in respect to salvage or other disposition. H. L. Seward, member A.S.M.E., served on this committee.

On May 1, 1942, the committee reported, recommending that the vessel be raised and the question of reconditioning be held in abeyance.

Capt. W. A. Sullivan, U.S.N., supervisor of salvage, undertook direction of the operations on the *Lafayette*. Owing to the size of the operation and the great number of other operations being conducted by the Navy Salvage Service and Merritt-Chapman & Scott Corporation, salvage was undertaken directly by the Navy using as little of key personnel of the Merritt-Chapman & Scott Corporation as possible.

In November, 1942, when Captain Sullivan was ordered to North Africa, Captain B. E. Manseau, U.S.N., who had been hull superintendent in the Navy Yard, Pearl Harbor, several years previous to and several months following the Japanese attack, succeeded Captain Sullivan in directing the salvage operations of the *Lafayette*. Lieutenant Commander C. F. Chandler, U.S.N.R., has been resident salvage officer charged with security of the pier and the *Lafayette*. Captain John I. Tooker, a Merritt-Chapman & Scott salvage officer, was made superintendent of the work on the *Lafayette*. M. C. Gilbert, 3rd, also of Merritt-Chapman & Scott Corporation, served as salvage engineer on the job and second in charge of salvage operations. A. C. W. Siecke, naval architect and consulting engineer, Merritt-Chapman & Scott Corporation, had charge of the entire program of stability and strength determinations.

Six hundred to eight hundred men have been regularly employed on the salvage job during the past year, of which as many as 75 have been divers. Upon their efforts as well as those of the supervisors and engineers hinged the success of the salvage plan. Three-hundred-fifty-six air ports, submerged an average of 60 ft below the surface and 8 to 10 ft in the mud, had to be patched and braced with reinforced concrete in order to withstand the water pressure that would be exerted on them when pumping was started.

TABLE OF WEIGHTS, CAPACITIES, AND VOLUMES

Portholes closed	356
Deck openings, patched, sq ft	5447
Estimated tons of debris and scrap removed	6000
Tons of superstructure removed	5000
Estimated pounds of broken glass removed	8000
Cubic yards of mud removed	10000
Board feet of lumber placed in ship by divers as shoring and bulkheads	240500
Number of wedges, plugs, and small patches (by divers)	4500
Total weight of large patches, tons	150
Tons of concrete added	1685
Number of 10-in. salvage pumps aboard	40
Number of 6-in. salvage pumps aboard	28
Number of 3-in. salvage pumps aboard	25
Total capacity of pumps, tons per hour	40000
Average number of men working on wreck	700
Average number of divers	70
Estimated total cost of salvage	$3,750,000
Actual cost of salvage up to June 1, 1943	$3,050,000
Estimated total volume of divers' air used, cubic feet. (standard temperature and pressure)	2,530,000,000
Tons of water inside ship to be pumped out	100000

In addition to these ports, certain cargo ports were open at the time of the disaster. They also had to be closed and backed with reinforced concrete laid under water. In patching, closing, and shoring of the air ports, cargo ports, and other openings, the great difficulties encountered by divers cannot be overemphasized. Because of the complexity of construction, divers had to find their way through devious passages, staterooms, and machinery spaces. Because of the silt in New York Harbor, these men had to work in total darkness for underwater lights cannot penetrate this murky water.

Before the divers could work in these submerged spaces, the spaces had to be cleared of the dunnage, debris, and miscellaneous stores and equipment with which they were filled. When the vessel rolled over, the furniture, stores, and all other portable objects contained inside of the vessel were dislodged and fell to port. The submerged portion of the athwartship passageways between the cargo ports in the ship's side, through which much of the access to the spaces requiring attention by the divers was obtained, were practically blocked with debris.

Almost all of the air ports and cargo doors, which required patching, were found to be covered with mud which had been squeezed into the ship through open or broken air ports or cargo doors. In many cases, divers found that some of the staging, hung on the portside of the vessel prior to the fire, had been crushed under the side of the vessel with many large timbers protruding at sharp angles through open ports, making the patching of these ports extremely difficult. In several cases, where both doors of cargo ports were open, more than 30 ft of mud had squeezed through. It was necessary for divers to enter these compartments, sometimes sinking over their heads in the mud, to clean out debris and direct mud discharge.

In most cases, mud was found to be 10 to 12 ft deep in way of open cargo ports. Moreover, divers spent months fighting the hazard of spun glass which had been used for insulation throughout the ship. It seemed that the fine glass penetrated the skin through the pores and could not be removed except by allowing time to let it grow out. Actually, the divers' lives were constantly in danger because of the broken glass and ragged steel edges, threatened to sever air and life lines.

In most salvage cases, the salvor must constantly be on guard against gas hazards arising from the decomposition of organic materials and the displacement of oxygen by any one of a number of causes, such as burners' torches and the operation of engines. Besides these usual dangers of gas, the salvors on the *Lafayette* were faced with additional hazards resulting from the organic material entering the ship from the slip. Two of the city sewers empty into the slip where the *Lafayette* lies. Extensive water tests were made early in the salvage operations to determine the extent of the hazard resulting from these organic materials. Various gas-testing devices and implements were used throughout the salvage of the vessel as a constant precaution against formation of gas. The fatal hydrogen sulphide was found at various times and the workmen were prevented from entering these compartments until proper ventilation had done away with the danger.

The salvage plan involved the completion of the following general operations:

1 Removal of the superstructure above the promenade deck above and below the water line.
2 Trimming of the promenade deck to prepare for the placing of patches on all of the openings.
3 Removal of all partition bulkheads, furniture, woodwork, and inflammable material inside of the vessel, both above and below the water line.
4 Closing sixteen cargo ports on the portside of the vessel and concreting and bracing port cargo hatches.
5 Closing 356 air ports on the portside of the vessel and patching and concreting the air ports.
6 Removing approximately 10,000 cu yd of mud.
7 Cleaning out boiler rooms, rearranging floor plates, securing boilers to foundations.
8 Cleaning out turbogenerator room and propulsion-motor rooms.
9 Patching all promenade-deck openings below the water line.
10 Installing timber and concrete bulkheads.
11 Shoring promenade deck.
12 Making intermediate deck tight; patching all openings.
13 Checking pumping arrangements. Closing all pipe lines in the vessel leading from one compartment to another.
14 Checking all available plans of ship to determine strength of bulkheads and decks for dewatering operations.
15 Installing and arranging forty 10-in. salvage pumps, twenty-eight 6-in. salvage pumps, and twenty-five 3-in. salvage pumps and piping for dewatering.
16 Making detailed calculations of stability and strength for righting operations.
17 Removing portion of the pier and driving fender piles.

After pumping operations had started, it became necessary to maintain complete control of the vessel at all times. The plan involved a pumping schedule which restricted the initial movement of the vessel to one of rotation on the port bilge keel rather than actual flotation. Mud suction, however, might restrict free movement to the extent that when the suction was broken, the ship might lurch to starboard. This uncontrolled flopping of the ship would be extremely dangerous since the vessel might crash into the pier. It was, then, of great importance that the mud suction be broken very gradually so that at no time would the vessel be out of control. This was accomplished by pumping down a certain amount, as was predetermined by stability calculations, and holding that pumped water level in the various compartments in order to let time help break the suction, rather than to set up tremendous stresses by extreme pumping. Water and air jets were installed to help break this suction if required, although their use was not required.

It was planned that the righting operations should commence during the latter part of the summer of 1943. Actually they began on August 6. The cleaning up of the ship and the removal of timber and concrete bulkheads must be done before actual reconstruction can take place.

Pumping operations were commenced with the vessel at the original 79-deg inclination. By August 15, pumping having proceeded under careful control, the vessel had righted to approximately 30 deg, at which point, removal of bulkheading and salvage gear was necessary eventually to bring the ship to an even keel. This work is now in process of completion.

Expenditures for salvage up to June 1, 1943, totaled $3,050,000. It is estimated that the total cost of salvage will be $3,750,000.

Steel Cartridge Cases

GENERAL MOTORS CORPORATION

DEVELOPMENTS in the manufacture of 75-mm steel cartridge cases at the Buick motor division, General Motors Corporation, were reported in a paper by R. B. Schenck at a meeting of the Society of Automotive Engineers.

The purpose of a cartridge case is to act as a container for the explosive charge, to prevent the escape of gases resulting from the explosion, and permit more rapid firing than would be possible without fixed ammunition. The wall of the case must be elastic enough to expand under the explosive pressure and make a tight seal against the breech wall of the gun. Unless it is properly supported by the breech wall, the pressure developed is sufficient to burst any case. A certain amount of clearance is necessary between the cartridge case and the breech wall to permit ease of loading and ejection under field conditions. The cartridge case must expand, first to take up this clearance, and continue to expand as the breech diameter increases due to the explosion pressure. The case must have enough elastic recovery to allow easy ejection after firing.

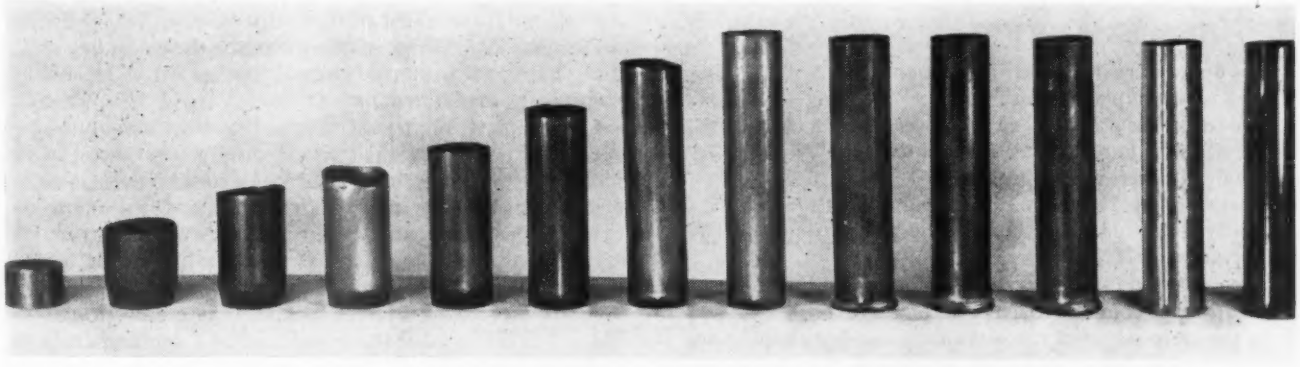


FIG. 1 FORMING OPERATIONS ON 75-MM STEEL CARTRIDGE SHELL FROM BAR TO FINISHED CASE

In contrast to the high physical properties required in the body of the cartridge case, the mouth must be annealed to insure complete obturation.

It is necessary to have a higher yield strength on a steel cartridge case than on brass because of the higher modulus of elasticity of steel. The modulus of brass is 14,000,000 against 30,000,000 for steel. The stress within the elastic range to produce a given amount of strain in brass is therefore approximately one half that of steel. Other considerations are corrosion and sparking, which must be overcome by suitable protective coatings. The steel cases must be interchangeable with the brass and function equally well in service.

In the selection of a material, a low-carbon steel was chosen which could be cold-worked and stress-relieved to the required physical properties without resorting to a spheroidizing treatment prior to cold-forming. Among the compositions tried during the development were S.A.E. 1015, 1016, and 1020, A.I.S.I. C-1019, and a higher manganese type containing 0.20 carbon and 1.29 manganese. Experimental lots of C-1019 included coarse-grained, fine-grained, aluminum-killed and silicon-killed steels.

FIG. 2 PRESS FOR FOUR DRAWING OPERATIONS

The composition finally adopted, and now in production is an open-hearth, high-manganese, aluminum-killed, fine-grained carbon steel.

The following is a list of the major operations performed in the manufacture of the 75 millimeter steel cartridge case at Buick:

1	Cut off	11	Draw	21	First taper
2	Grind OD	12	Trim end	22	Second taper
3	Heat	13	First cold-redraw	23	Flame-anneal
4	Extrude	14	Second cold-redraw	24	Machine base
5	Redraw hot	15	Third cold-redraw	25	Face to length
6	Size cold	16	Trim end	26	Finish-beam and counterbore
7	Anneal	17	Fourth cold-redraw	27	Inspect and repair
8	Pickle and rinse	18	Bonderize	28	Draw
9	Coin-head	19	Cold-head	29	Phosphoric - acid pickle
10	Bonderize	20	Flame-anneal	30	Paint
				31	Bake

The appearance of the case at various stages of manufacture is shown photographically in Fig. 1.

The centerless grinding (step 2) serves to provide a more perfect surface, eliminating defects which would tend to carry through the subsequent operations.

Heating (step 3) for the hot-cupping operation is done in a specially built induction heater, the piece being brought to temperature in $1^1/_2$ min.

The extrusion (step 4) is done in a standard forging press of the crank type common to many automotive shops.

In the early stages of the work only one hot-cupping operation was used, but it was later determined that better results could be obtained if a second hot operation was carried out after the piece had cooled somewhat. The second hot press is the same as the first, except for slightly altered tooling extending the draw two inches further, or to about six inches.

After the original setup was worked out, an extra operation was added to control the wall thickness. The cup is cold-sized in a press, drawing it out only slightly. This is done after the hot-redrawn cup has cooled in air.

After annealing, followed by acid pickling and washing to remove scale, the head of the cup is coined in a crank case.

Perhaps the most interesting step in the entire operation is the series of four cold-drawing operations (steps 13–17), all carried out on a single 750-ton Clearing double-acting press. See Fig. 2. The four punch and die stations are placed to form the four corners of a rectangle well within the normal platen area and are so arranged as to carry approximately an equal load of somewhere near 150 tons per station. The depth of draw varies slightly over the four dies, being controlled by the length of the punch. The cartridge case progresses from the left-hand die to the right-hand die on one side of the press and is then handed through the die opening and placed on the die directly across from the second station, finally moving to the right-hand die on that side. Four operators handle the press, one at each die. Each punch has an integral mechanical stripper which removes the part after drawing.

On this press, the six-inch cup is drawn to 15 in. and to the approximate form of the finished case, a total draw of nine inches with no substantial change in diameter. This is a real test of the drawing qualities of the steel, and it is noteworthy that few pieces are torn or split in these severe operations. A special drawing compound was developed, the base material of which is machine oil.

Annealing before tapering (step 20) is quite critical. See Fig. 3. It is limited at the mouth end to a depth of about two inches to prevent splits during tapering. The temperature is closely controlled. In this operation, the cases are mounted

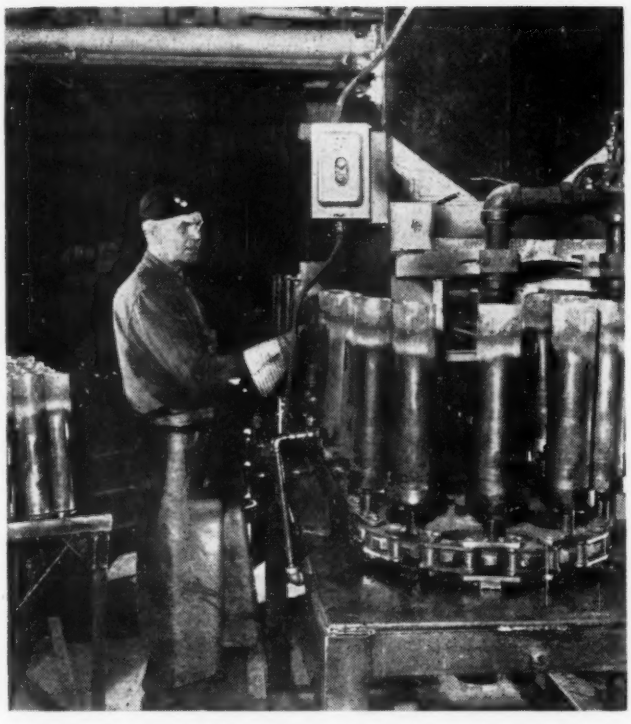


FIG. 3 ANNEALING MOUTH BEFORE TAPERING

on a conveyer and moved between two rows of $2^1/_2$-in. radiant gas burners. These are mounted in a furnace horizontally at the proper height to concentrate the heat on the mouths of the cases as they travel through the furnace. The cases are rotated slowly as they move past the burners.

Tapering operations are perhaps the most critical of all steps since, in these two press operations, the cold steel must be made to flow into the desired taper without wrinkling or distortion and without the support of a punch on the inside. The case is simply forced up into a tapered die cavity in two stages, both on the same press. The second stage does have a punch which extends about three and one-half inches into the case. This is required not for the over-all taper but to support the metal in forming the reduced section at the mouth.

Punches used on all the cold-drawing and tapering operations are made of hardened high-speed steel chromium-plated. The plating improves the wearing qualities and provides better antifrictional properties. Lower dies in the cold operations are generally steel rings with tungsten-carbide inserts on the working surfaces.

The coating specified to provide protection against corrosion and sparking is an unpigmented baked phenolic varnish. Before painting, the cases are given a phosphoric-acid pickle which provides a bond for the paint and also some additional protection against corrosion. The painting and baking operations are fully automatic, the cases being mounted vertically on a conveyer with the open end up.

Once coated, the cases are carried slowly between two banks of infrared lamps, 64 on each side. The conveyer loops twice at the end of the lamp bank so that the cases travel three times through the baking zone requiring 48 min in a temperature approximating 360 F. When they emerge at the opposite end from the painting station they pass through an exhaust cooling hood and out to an unloading station where they are thoroughly dry and cool enough to handle.

Centrifugal Casting of Bushings

MECHANICAL WORLD

A CENTRIFUGAL casting machine with a movable axis which can, at will and while running, be set at any required angle to the horizontal is reported in the August 20 issue of *Mechanical World* (England). A general arrangement of the machine will be seen in Fig. 4. Fig. 5 shows a typical bushing which can be cast using plaster-of-Paris molds. It is possible to get a range of speed from zero to 3000 rpm on the spindle shaft. The angle of the spindle may be altered while the motor is running, a feature which should prove of value when the molten metal is being poured. When making small castings with a mold in a horizontal position it is difficult to

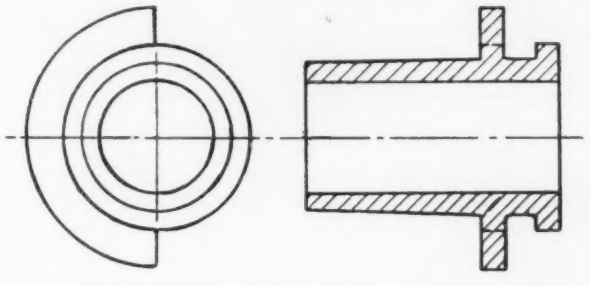


FIG. 5 TYPICAL BUSHING CAST CENTRIFUGALLY USING PLASTER-OF-PARIS MOLDS

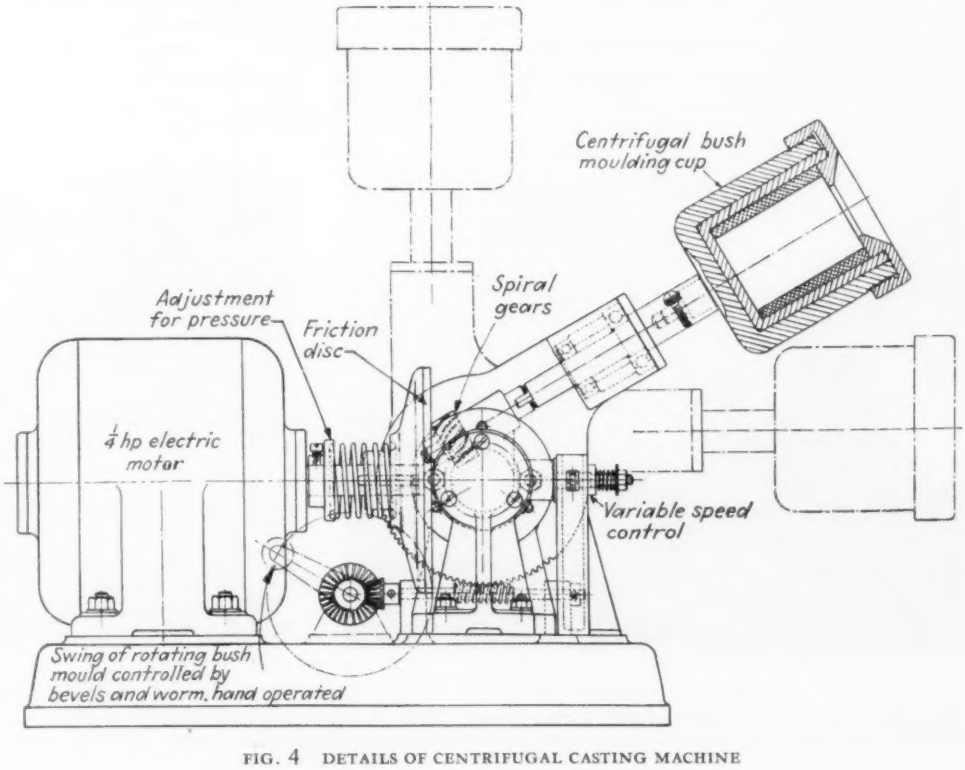

Centrifugal bush moulding cup
Spiral gears
Adjustment for pressure
Friction disc
¼ hp electric motor
Variable speed control
Swing of rotating bush mould controlled by bevels and worm, hand operated

FIG. 4 DETAILS OF CENTRIFUGAL CASTING MACHINE

introduce the stream of molten metal fast enough to insure distribution evenly over the mold surface. The most suitable angle for the spindle can be determined only by experience and in relation to the length and axial section of the casting. It must be kept in mind, however, that as the angle of the revolving mold is decreased the impurities in the metal, which in the case of the vertical spindle would concentrate at the top, will begin to fall back.

Punch and Die

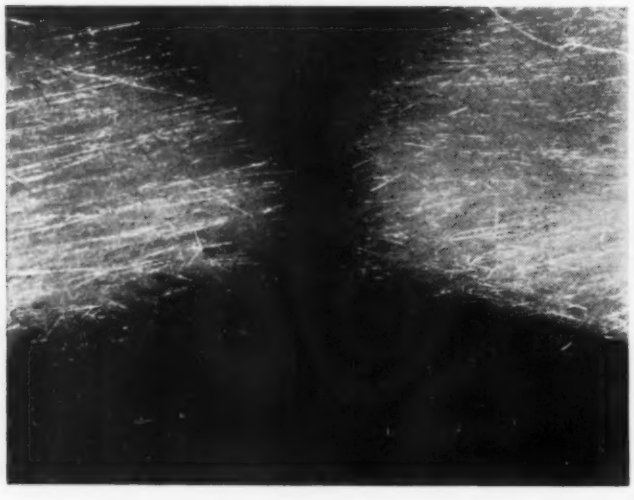
THE MODERN INDUSTRIAL PRESS

THE Curtiss-Wright Corporation has made a successful test run of several hundred sheet-metal parts formed on a drop hammer equipped with a newly developed all-plastic punch and noncritical metal die, according to a brief article in *The Modern Industrial Press* for August, 1943. The plastic used in the punch is not specified beyond the statement that it is "a refinement of other types of plastics used previously in earlier experiments." The lower die is made of "Kirksite," developed to relieve the demand for critical tool steels.

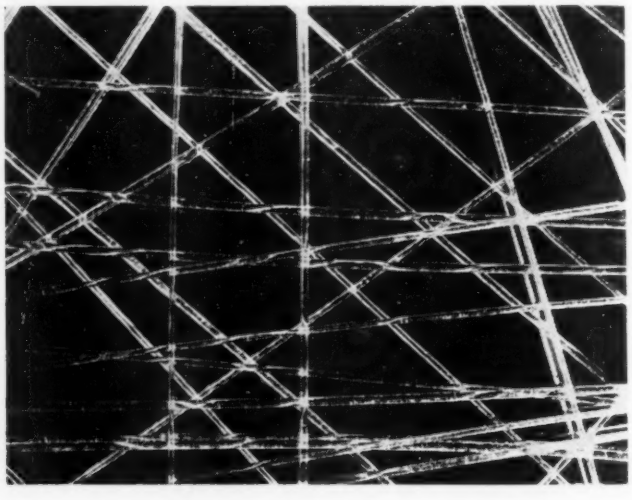
Says the article referred to: "Capable of becoming malleable when heat-treated, the punch saves three quarters of the time formerly spent in tooling due to the fact that it can be shaped into a perfect fit with the die in a single operation. The die is heated to approximately 370 F and the plastic punch, roughly shaped for mating contours, is placed on the die and pressed into it."

Another feature of the punch, which was developed to form sheet-metal parts, is the elimination of rubber pads and strips to absorb shock and protect metal surfaces. The plastic nature of the punch absorbs shocks and the metal part is said to be formed with fewer blows.

As the punch wears it may be dressed by heating the die and again pressing the punch into it. Used punches are reclaimable.



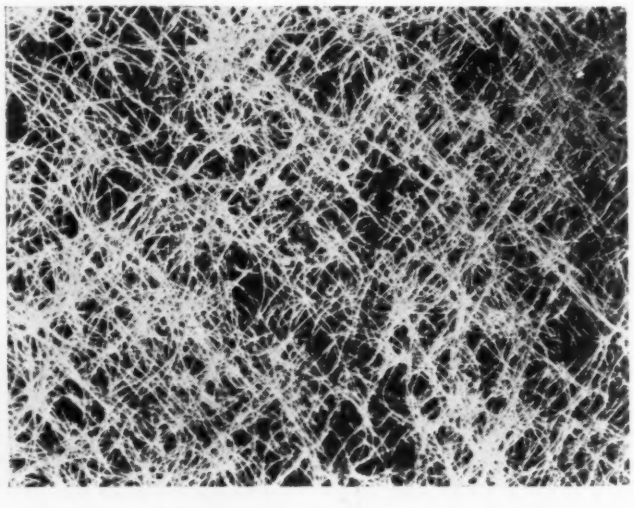
NO. 800 GLASS FIBERS (LEFT) AND NO. 450 GLASS FIBERS (RIGHT) ARE COARSE FIBERS SUITABLE FOR FILTERING, EVAPORATING, AND CONTACT MAT APPLICATIONS WHERE LOW RESISTANCE IS REQUIRED



PHOTOMICROGRAPH OF NO. 800 GLASS FIBERS, SUITABLE FOR FILTERING, EVAPORATING, AND CONTACT MAT APPLICATIONS WHERE LOW RESISTANCE IS REQUIRED

(Glass fibers resemble smooth, solid glass rods of very small diameter. Individual fibesr are nonhygroscopic and nonabsorbent. Average fiber diameter of the No. 800 fibers is 0.0080 in.; of the number 450 fibers, 0.0045 in. Surface area per pound of the No. 800 fibers is 38.7 sq ft; of the No. 450 fibers, 68.8 sq ft.)

PAD OF NO. 115K GLASS FIBERS



PHOTOMICROGRAPH OF NO. 115K GLASS FIBERS

(These fibers are characterized by their "curly" nature. Each fiber is crinkled or waved throughout its length to provide very low density and high resiliency. The glass composition offers maximum resistance to acid conditions. Average diameter of the fibers is 0.00115 in. Surface area per lb is 262 sq ft.)

Submachine Gun, M3

ARMY ORDNANCE

IN an article by Col. René R. Studler describing briefly the new submachine gun, M3, now the standard submachine weapon of the U.S. Army, considerable space is devoted to the method by which it was brought into being and the tests to which it was subjected before its adoption.

The need for such a weapon as the M3 submachine gun, according to the article by Colonel Studler in the September-October issue of *Army Ordnance*, was first foreseen in July, 1942, when it became evident that production capacity then available for submachine guns of the type required under war conditions was inadequate to meet the growing demand for such weapons. Expansion of existing facilities was out of the question. Machine-tool capacity was even then being diverted to high-priority projects. What was required, in effect, was a gun of improved performance characteristics that used neither the raw materials nor the machine tools normally required in gun manufacture.

Within four months an experimental gun which met these almost impossible requirements was ready for test. After engineering tests indicated that the new gun had extraordinary possibilities, it was tested in rapid succession by the Infantry, Parachute Troops, Amphibious Troops, Armored Force, and the Tank Destroyer Command.

The Infantry reported that in comparison with standard weapons the new submachine gun was more accurate, easier to control, had less recoil, and a slower rate of fire which made each shot more effective. The Parachute Troops preferred it because of its lighter weight and collapsible stock. The Amphibious Troops found that rain, salt spray, or even complete immersion in sea water had little effect on its reliability during landing operations. The Armored Force reported that even under conditions of excessive dust incident to tank operation in the desert it could be depended on to deliver accurate deadly fire. The Tank Destroyer Command found that its sturdy all-metal construction stood all the battering that a high-speed motorized gun mount could give it. At the climax to this series of tests the Ordnance Department stated that it was superior in all respects to every comparable foreign weapon.

So overwhelming was the superiority of the new submachine gun that it would not be possible to supply American soldiers with any other submachine gun and maintain a clear conscience. So carefully planned was the design and so well organized was the procurement program that less than ten months after the need for a new submachine gun was first established, the weapon was coming off the assembly line in large quantities and at an ever-increasing rate.

At 10:00 a.m. on April 30, 1943, the first of the U. S. Army's new guns came off the production line. Known officially as the M3 submachine gun, this weapon at first glance resembles the equipment used by "Buck Rogers." The outstanding features are: Reliability of functioning, accuracy, portability, a low rate of fire, and endurance when operating under adverse conditions of mud, dust, and water. When it is field-stripped it can be packed in a box $12^{3}/_{4} \times 7^{1}/_{2} \times 3^{3}/_{8}$ inches. No tools are required in taking the gun down or assembling it. This weapon is simplicity itself. When disassembled there are only 25 component parts and 73 pieces made by the manufacturer (less magazine). It is all-metal, fabricated mainly from stamped parts to take advantage of speed and economy of manufacture and assembly. As standardized, the M3 uses the standard caliber 0.45 ball-cartridge ammunition. A magazine feed of 30-shot capacity will fire at the rate of 450 rounds a minute.

The new gun employs the straight-blowback full-automatic principle. Single shots can be made by the quick depression and release of the trigger. This is possible because of the slow motion of the bolt and the low rate of fire. The bolt has a fixed firing pin and is so designed that the excess energy from its forward motion is expended simultaneously with the explosion of the cartridge. This available energy is to counteract the muzzle rise in recoil of the weapon, thus improving accuracy of fire. This gun has an 8-inch barrel, a sliding removable stock, and weighs eight pounds (less magazine). All working parts are fully enclosed to protect them from dirt, dust, mud, and water. There are no projecting moving parts to endanger the operator. The ejection port cover is also a safety device to insure a closed safe gun when it is not in use. The safety lug on the cover, when it is closed, locks the bolt on an empty chamber when it is forward. In the cocked position, the safety lug holds the bolt back off the sear and makes the sear and trigger both ineffective.

When this new M3 was standardized, former standard submachine guns were classified as limited standard. This action will gradually release facilities making the former weapons for the manufacture of other necessary items. This is possible because the M3 submachine gun can be produced without complicated machine tools, and since most of the components are made by the metal-stamping process, many facilities equipped to do this type of work, which have been previously unable to take part in the war effort, can be utilized.

The savings involved in switching to the exclusive manufacture of the new gun are enormous, whether viewed from the standpoint of money, man-hours, or machine tools. The first submachine gun bought by the Army in 1928 cost upward of $200. Fifteen years later, after several hundred thousand had been made, these same guns with comparatively few modifications cost about $40 apiece. Contrast these figures with a unit cost of less than $20, a 50 per cent reduction in man-hours, and a 25 per cent reduction in machine-tool requirements for the new submachine gun and you have a combination which means dollars to the taxpayer, manpower to the Army, machinery to the manufacturer, and trouble to the Axis.

Industrial Electronics

INDUSTRIAL ELECTRONICS CONFERENCE

AT a conference on industrial electronics, Schenectady, N. Y., Sept. 14, 1943, which reviewed what electronics has done, is doing, and can do in industry, it was pointed out that hundreds of electronics equipments are now available to industry to help do jobs better and to take over jobs that could not be done otherwise. Welding, heat-treating, positioning, speed matching, current and voltage control, temperature control, color matching, motor control, inspection and counting, process control, measurements and testing, power rectification and frequency changing, industrial X rays, precipitation, and decorative lighting are some of the fields falling within the scope of this equipment.

Speakers at the conference were: L. A. Umansky, assistant manager, industrial-engineering division, General Electric Company, who spoke on the broad aspects of industrial electronics; W. C. White, engineer of the electronics laboratory, who told of the variety and types of electron tubes available for industry; L. W. Morton, of the industrial-engineering division, who covered electronics in power conversion and frequency changing; W. C. Hutchins, manager, special-products division, who told of the application of electronic measuring equipments; J. P. Jordan, electronics section, industrial-heating engineering division, who described electronic heating; and E. H. Alexander, engineer, industrial-control division, who discussed electronic controls. W. C. Yates, assistant manager, industrial division, presided.

In pointing out how electronics has already come to maturity in industrial operations, Mr. Umansky said that 1943 will see 25

THYRATRON HALF-CYCLE WELDING CONTROL PANEL USED WITH BENCH WELDER FOR SPOT-WELDING VACUUM-TUBE ASSEMBLIES

billion kilowatthours of electrical energy passing through electronic devices. He told how the application of electronics has brought about changes in many manufacturing industries and gave as an example the contributions of electronic control to bring previously unknown precision, speed, and reliability to resistance-welding operations, thus making possible the mass-production fabrication of many of today's implements of war.

"No one familiar with industrial engineering," he said, "considers any longer as a daring or pioneering feat the use of electron tubes for accurately controlling the speed or acceleration of motors; for precision positioning a sheet of paper on a printing press; for color matching; for controlling wire tension; for smoke detection; or for temperature control—to mention a few of the hundreds of electronic applications that have passed from the laboratory to the factory stage."

Mr. Umansky pointed out that he looked upon electronics as another tool—a very important one, to be sure—added to a well-filled tool chest and to be used side by side with other tools on hand. In the true perspective of things, electronics has taken its place as an equal partner, side by side with other electric equipments, enhancing rather than superseding them.

ELECTRON TUBES

In describing the variety and versatility of modern electron tubes, W. C. White stated that tubes are available that will detect and measure currents of far less than a billionth of an ampere. Others will carry thousands of amperes. Similarly, voltages of a millionth of a volt can be detected and amplified, and rectification up to one hundred thousand volts provided for. On the frequency scale, tubes are available to provide frequencies up to about a billion cycles. Physically, some tubes are so small that they will fit into a thimble; others are bigger than a man.

In the fundamental classification of tubes, there are only four basic component variables: (1) The nature of the cathode that emits the electrons; (2) the nature of the content of the envelope; (3) the number of electrodes; and (4) a special feature sometimes added to the first three basic components to adapt a tube to some particular use. Under this classification, the ignitron is a pool-cathode, vapor-content, three-element tube.

The usefulness of the electron tube as a circuit element is based upon many characteristics but in general, according to Mr. White, these can be reduced to certain rather simple fundamentals. The first of these is the tube's almost complete independence of action as regards circuit frequency. A vacuum tube can function at millions of cycles a second just as well as at 60 cycles. The second is the ability of the electron tube to control electrical currents smoothly, without the steps required by other devices to vary an electric current. The third feature is its ability to amplify. The fourth feature is its ability to pass current in one direction only or, as it is often expressed, to act as a rectifier.

"The present trend in tube development appears to be along the line of stepping up their characteristics over a severalfold range, so that future tubes and their associated circuits will be able to handle currents several times as heavy as present tubes now handle," Mr. White said. "It will mean that frequencies ten times as high as those in common use can be generated and utilized. Working in the opposite direction, there will be a trend toward tubes that fundamentally respond to weaker impulses, that is, have a high degree of amplification or that will time electrical-circuit operation for much shorter periods and with much greater accuracy than we now enjoy."

POWER CONVERSION AND FREQUENCY CHANGING

Electronics as applied to power conversion means rectification, or the conversion of alternating-current power supplied from an alternating-current system to direct current for direct-current power utilization processes or systems, explained L. W. Morton. The predominant equipment in this field is the mercury-arc rectifier which utilizes tubes which contain mercury vapor as the gas. The mercury-arc action is of such a nature that current cannot flow through the vapor when the anode is negative with respect to the tube's cathode, which is really a pool of liquid mercury.

In this application, the ability of electron tubes to pass current in only one direction is put to work. The alternating-current system is connected to anodes and as each anode becomes positive it conducts unidirectional or direct current, thus resulting in a continuous flow of direct current from the tube cathode.

Mr. Morton pointed out that the mercury-arc power rectifier is one of the oldest electronic devices. An early commercial application was made in 1924 when a 500-kw multianode rectifier was installed in Albany, N. Y., to convert power supplied to 600-volt street-railway service. Since then one company alone has supplied almost a million and a half kilowatts of rectifiers of steadily improved design and efficiency to electrometallurgical and electrochemical processes, transportation service, steel mills, mines, printing-press drives, shipyards, and cracking processes, and to convert power for cranes, elevators, ore bridges, and car dumpers.

"The application of electronics in the shape of power rectifiers has expedited the recent expansion of facilities for producing light metal in two ways," said Mr. Morton. "If electronic power-conversion equipment had not been available, industry's requirements for 2,500,000 kw of conversion apparatus for aluminum and magnesium would have had to be met by rotating equipment. The facilities for the manufacture of rotating equipment were so heavily taxed by other war requirements that the addition of this additional requirement would probably have delayed the light-metals program for several months."

"In addition," he pointed out, "since rotating conversion apparatus requires roughly 50 to 100 per cent more steel and 25 to 75 per cent more copper than electronic rectifiers, it has been

estimated that more than 40,000,000 pounds of steel and 3,750-000 pounds of critical copper have been saved for other industrial fronts."

Mr. Morton pointed out that the same principles used in converting power from alternating to direct current could be slightly modified to convert direct current to alternating current. Thus, by combining two rectifier equipments, one for use as a rectifier to convert power from an alternating-current supply to direct current and another to change that direct-current power to alternating current and deliver it to another alternating-current system, power can be transferred between two alternating-current systems of different frequencies.

A pioneer direct-current transmission system operated by the New York Power and Light Corporation has been in operation for several years and takes power at 40 cycles and delivers it to another system seventeen miles away at 60 cycles.

An electronic frequency changer rated 20,000 kw which will connect a large steel company's 25-cycle power system and the power company's 60-cycle system will be put in service in the fall of 1943. In this case, the direct-current link will be less than 12 ft long. The apparatus will be able to deliver constantly any desired kilowatt rate within the 20,000-kw rating from either system to the other.

ELECTRONIC MEASUREMENTS

Mr. Hutchins described a few of the many electronic instruments available to industry to perform a wide range of testing and measuring. He told about the new electronic winding-insulation tester which is helping to make better motors. By simulating unusual stresses to which the motor may be subjected after installation, such as those caused by lightning or swiching, this instrument makes it possible to detect damaged insulation in the motor windings.

The measurement of sound is essential in the manufacture of quiet operating apparatus, whether it be an air-conditioning equipment in a theater or war equipment that must be quiet to prevent giving away the positions of our soldiers to the enemy. A sound-level meter, utilizing a specially designed microphone in combination with an electronic circuit, has made it possible to convert the noise or minute sound pressure waves to an accurate numerical value.

The electronic vibration-velocity meter has made it possible to measure and analyze vibrations in high-speed machines more accurately than was possible without the use of the electron tube.

Heat exchangers, with water flowing through tubes and air passing over the outside, are required for the operation of submarines and battleships. Since a leak in one tube may cause thousands of dollars damage, testing of these brass tubes became important in manufacture. After conducting every conventional test, faulty tubes were still getting into the finished heat exchangers. The replacing tube cost only $1, but the cost to install the tube amounted to $250. A tube flaw detector, a high-frequency electronic equipment, was installed. The saving resulting from the rejection of tubes with flaws before the tubes were installed, saved the price of the installation in less than three months, and speeded up production.

"The science of electronics," said Mr. Hutchins, "has enabled the engineer to build equipment that is almost human in that he has practically duplicated four of the human senses. To illustrate, the mercury-vapor detector simulates the sense of smell; the sound-level meter the sense of hearing; the vibration meter the sense of touch; the photoelectric tube the sense of sight, even to the extent of distinguishing colors more accurately than is possible with the human eye."

ELECTRONIC HEATING

"Electronic heating," J. P. Jordan pointed out, "covers the application of high-frequency vacuum-tube oscillators to two broad fields: The induction heating of metals and the dielectric heating of nonmetallic materials such as plywood, plastics, and foods. Although the equipments for both applications are somewhat similar, the methods of heat generation and its effects on the charge differ widely."

In induction heating, he explained, the part is placed in or adjacent to a water-cooled inductor coil which carries a high-frequency alternating current. The magnetic field thus produced induces a current in the surface of the part and causes it to be heated. This heat is generated entirely in a surface layer, the depth of which is determined by the frequency used.

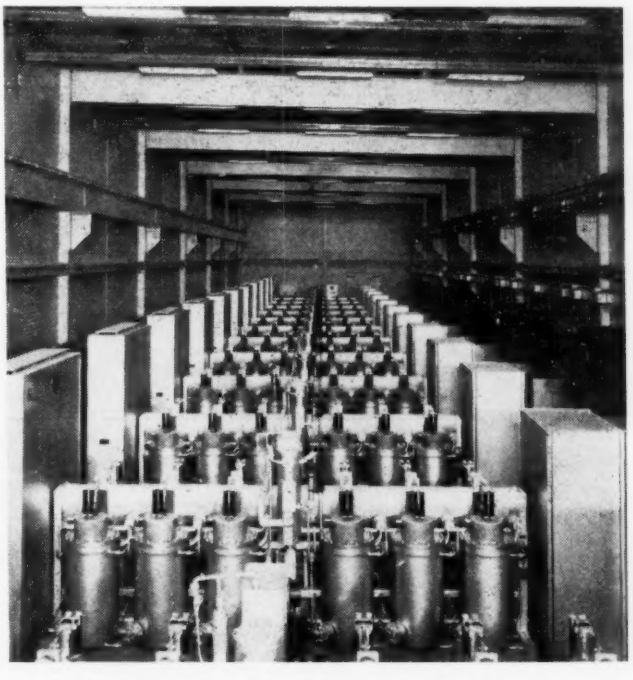
On the other hand, in dielectric heating the material is placed between two plates, thus forming a capacitor; a high-frequency voltage is then applied and considerable power in the form of heat is distributed throughout the material being treated.

"On the basis of cost per kilowatt of heat generated," Mr. Jordan explained, "electronic heaters represent at the present time the most expensive form of heat obtainable. Due to the emphasis being placed on electronics today, it would be all too easy to select such equipment for applications which later would prove to be uneconomical and thus prejudice the further use of electronic heaters. Therefore it is important that electronic heaters be applied only to those processes where their unique characteristics can be used to best advantage."

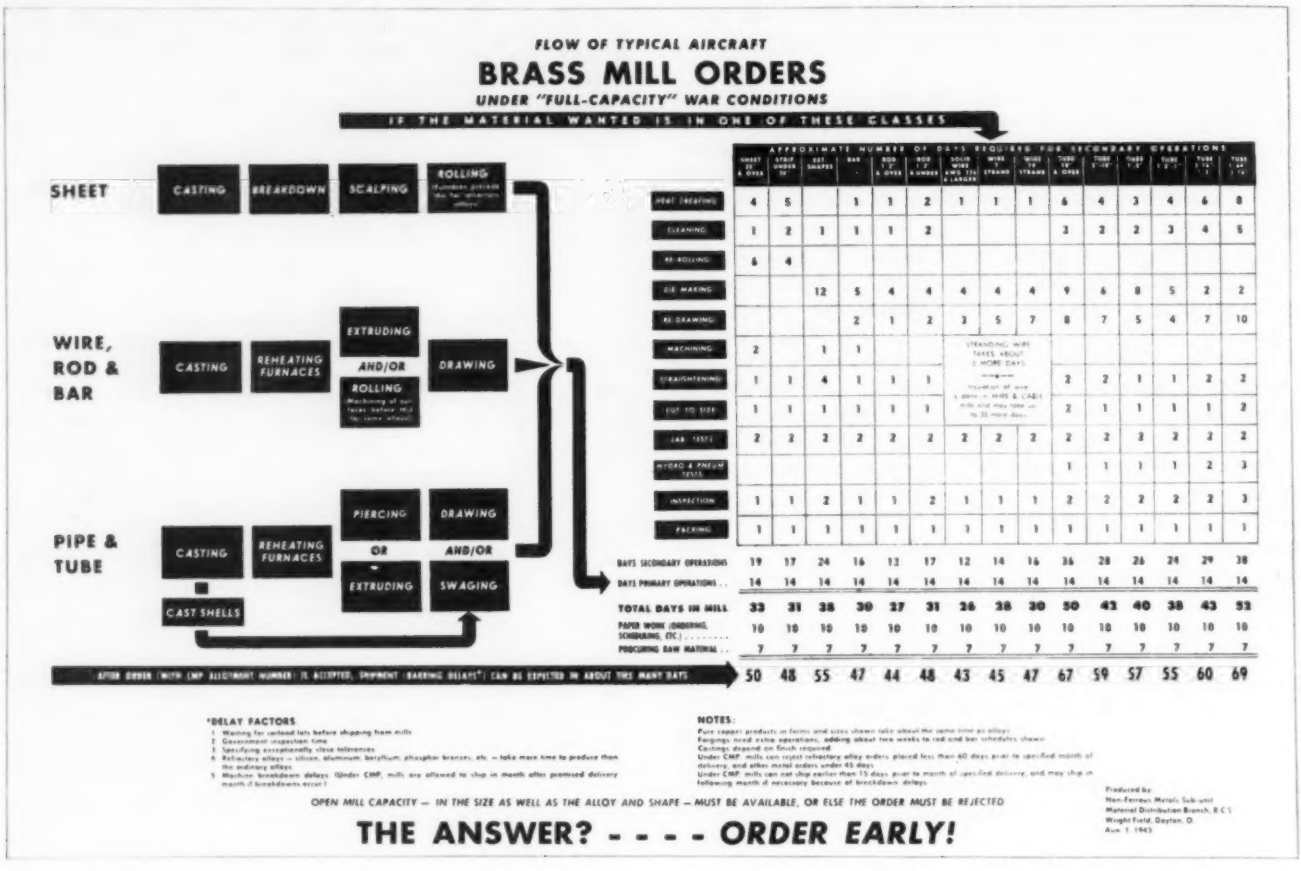
Mr. Jordan went on to point out that since this type of heat permits its concentration on the surface of sharply defined areas, it is invaluable in the surface-hardening of gears, bearings, and other parts subject to surface wear. Previously, such parts were either hardened throughout, thus sacrificing ductility and toughness, or were casehardened by standard methods which involved several time-consuming operations and often resulted in distortion and scale.

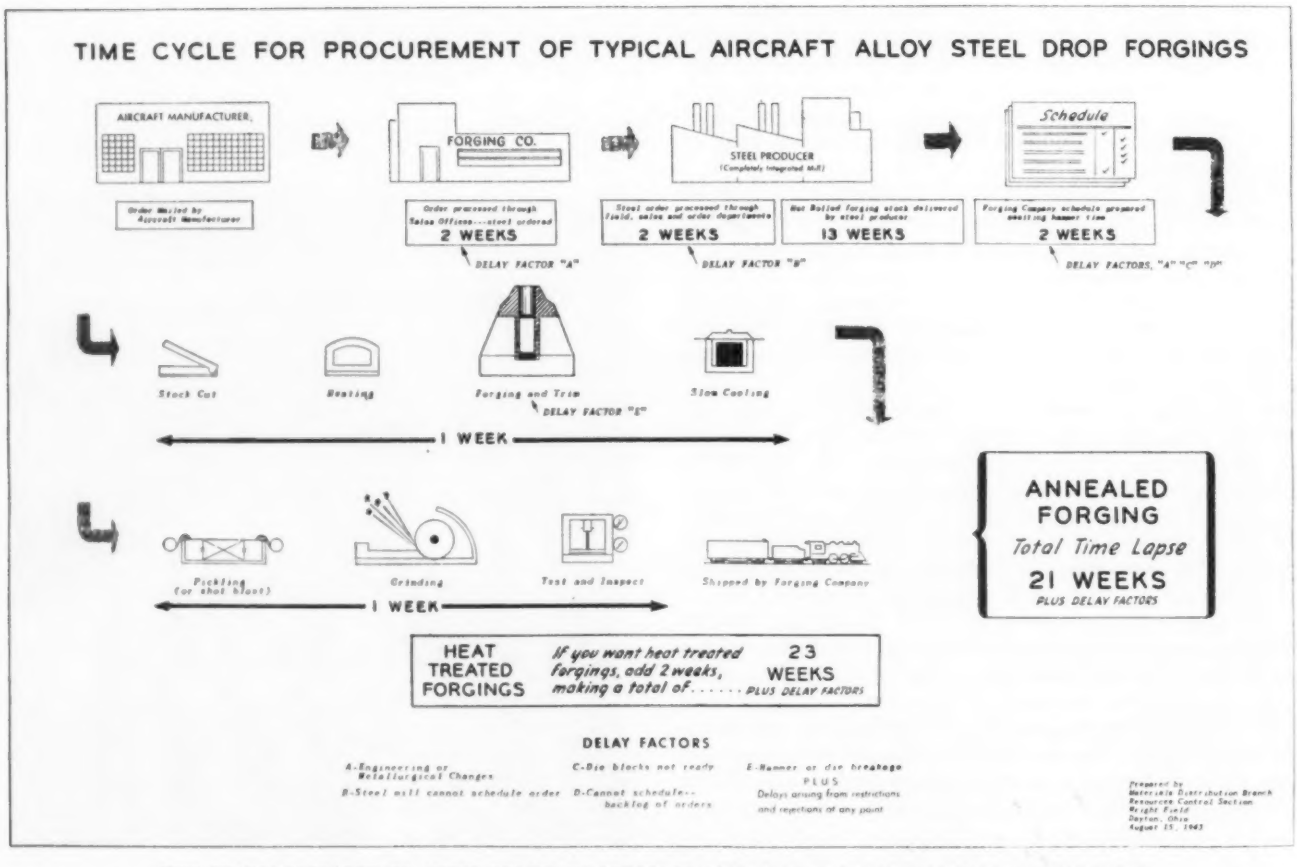
In the brazing field, the main advantages are uniformity of results and automatic operation, independent of the operator's judgment. Electronic heaters always produce the same temperature in the same area.

In the dielectric heating field, the gluing of plywood and the preheating of plastics are the major applications to date. When relatively thick sections of plywood are glued in a steam press, the rate of heat transfer through the mass is very slow, thus the surface must be held at temperature for periods up to



TWELVE-UNIT IGNITION MERCURY-ARC RECTIFIER INSTALLATION IN ELECTROCHEMICAL PLANT
(Rectifier units are rated 5000 amperes, 645 volts.)





TWO CHARTS PREPARED TO AVOID DELAYS IN ORDERING BRASS MATERIALS AND ALLOY-STEEL FORGINGS

(Copies of these charts may be obtained from the Materials Distribution Branch, Resources Control Section, Army Air Forces, Wright Field, Dayton, Ohio. The Aircraft Scheduling Unit, also at Wright Field, has issued a new catalog of 71 brass mills to show which of each of 8 major products each mill produces in order to avoid lost effort in placing orders.)

several hours before the center is heated sufficiently. Electronic heaters raise the temperature uniformly throughout the mass and thus eliminate heat conduction as a factor and greatly reduce the heating time required.

In the molding of thermosetting plastic parts, it has heretofore been necessary to place uncured plastic pellets in a mold while the pellets were relatively cold. Efforts to heat them with hot plates or infrared lamps prior to molding resulted in the outside surfaces' being cured before the interior was appreciably heated. With dielectric heat, the entire mass can be brought to a high temperature without danger of localized curing.

ELECTRONIC CONTROL

E. H. Alexander stated that no single industrial electronic equipment has contributed more to war production than resistance-welding control. Precision timing and heat control have made it possible to fabricate many new and special metal alloys.

An important recent contribution to the art of resistance-welding control is the electronic current-regulating compensator. The current regulator compensates for variations in line voltage and for the amount of magnetic material in the throat of the welding machine, thus making it possible to obtain consistent welds in welding parts of irregular and varying shapes.

The increased use of aluminum alloys, especially in heavy gages, has brought forward the energy-storage method of resistance welding to supply the very high currents required by these materials. In this system, an electronic rectifier takes power from alternating-current lines and converts it to direct current which is stored, usually in capacitors. The voltage stability of the power supply is thus greatly increased since the current demand is reduced and the load divided over three phases.

Describing an electronic motor-control drive, the Thy-motrol, Mr. Alexander explained that with this drive it is literally possible to make a direct-current motor do useful tricks with power supplied from an alternating-current line. Thyratron tubes change the alternating-current power to direct-current and make it possible to operate the motor over a wide speed range; and start, accelerate, decelerate, regulate, and reverse, simply by turning a tiny dial or pushing small buttons.

"Automatic timing of industrial processes has always been an important problem," said Mr. Alexander. "The seemingly simple job of accurately measuring increments of time in a series of repeated sequences has been tackled and solved in many mechanical ways, but usually by resorting to some form of motor-driven gear train and cam. Without a single moving element, except the electromagnetic relay itself, electronic timers afford an accurate, simple, and readily adjustable solution to the process-timing problem. The life of the equipment is measured in terms of tens of millions of operations, whereas two million operations without repair or adjustment would be an exceedingly long life for a mechanical timer."

One of the milestones in the use of electronic control was the application of thyratron control in 1929 at the Chicago Civic Opera Company. This equipment provided control for 160 lighting circuits, any of which might handle several kilowatts of lighting load. A more recent application of large-scale electronic control is in operation at Radio City Music Hall. Control for 313 lighting circuits and five preset scenes in addition to the control of the scene undergoing presentation is provided. Nerve center for the 1500 electron tubes handling this job is a centrally located operator's control board.

"Perhaps the best known electronic control is the photoelectric control, whose manifold applications to countless industrial operations exceed those of all other industrial electronic devices in quantity and variety," said Mr. Alexander. "To control a device or process without touching it, such as guiding a web of fragile tissue, counting a freshly painted object or a sterile article, or checking or regulating the temperature of a white-hot heat process, renders the phototube and its associated equipment a real industrial tool."

The phototube is playing a most important part in high-speed processes, such as policing the printing of paper moving at 1000 feet per minute, to assure that all colors are in register; detecting pinholes in steel strip moving as fast as 1000 fpm; holding tension on loops of continuous web or strip of material being processed in different machines at high speeds; holding steel strip in register as it is being coiled so that the coils will be uniform; and many similar applications.

Radionics

DEVELOPMENTS in electronics, such, for example, as those discussed at the recent conference in Schenectady reported elsewhere in this section, indicate the growing necessity of mechanical engineers to acquire information on the subject. Two publications that are directed to this end have recently appeared: "Reference Data for Radio Engineers," published by the Federal Telephone and Radio Corporation, an I. T. and T. associate; and "Trail Blazers to Radionics and Reference Guide to Ultra High Frequencies," compiled by E. Kelsey, engineering correlator, Zenith Radio Corporation.

In compiling "Reference Data for Radio Engineers" the aim was to provide for the requirements of engineers as well as practical technicians. A small first edition was prepared for presentation to Army, Navy, and government agencies, educational institutions, and engineers on the staff of the International Telephone and Telegraph Corporation and its associate companies. The second printing of this first edition is now available for sale by the company at $1 per copy.

The Zenith publication contains twenty-one brief biographies of "trail blazers to radionics," from Phythagoras to Farnsworth, from Ampere to Zworykin, each augmented with a brief bibliography. The second section of the publication contains 56 pages of selected bibliographical references, arranged in groups according to subject matter, prepared by Miss Kelsey. Copies are available on request to the Zenith Radio Corporation.

RADIANT HEATING IN NEW PLANT

(The one-story addition of the Murray Corporation, Townson, Md., has no basement and is heated by steam coils laid in the floor. Straight rows of 1¼ in. wrought-iron pipe are welded to end sections to form three banks of grids. Finished coils are laid on strips of 1-in. Celotex resting on 6 in. of concrete.)

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Note on Fitting a Physical Property Mortality Curve[1]

To the Editor:

The validity of a function of the form

$$y = kab^x \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

to interpret a phenomenon may be explored through the use of a special form of graph paper which will be described.

Equation [1] is the result of integration of the differential equation

$$\frac{1}{y}\cdot\frac{dy}{dx} = cb^x \ldots\ldots\ldots\ldots [2]$$

which expresses a relationship wherein the percentage rate of change of the function, i.e., the "logarithmic derivative," is an exponential function of the independent variable. Equation [1] has especial application in the theory of depreciation of physical property such as machinery, mechanical and electrical equipment, rolling stock, and structures. For this application Equation [1] is known as the "Gompertz survivor equation" and, in the conventional notation, is written

$$l_x = kg^{c^x} \ldots\ldots\ldots\ldots\ldots [3]$$

where x is expressed in time units; l_x is the number surviving ("living") at time x; g and c are constants to be derived from experience data. Engineering research has shown that Equation [3] is appropriate for describing the mortality characteristics of certain types of physical plant, yielding results equally as satisfactory as those produced by the Makeham equation.

By the use of log-colog graph paper it is possible to approximate the constants for Equation [3], and to extrapolate Equation [3] graphically into the region beyond that covered by experience data. The theory of the process and the construction of the graph paper is explained in the following paragraphs:

From Equation [3], the "yearly probability of survival," denoted by p_x, is

$$p_x = \frac{l_{x+1}}{l_x} = \frac{kg^{c^{x+1}}}{kg^{c^x}} = g^{c^x(c-1)}$$

Now, since $l_{(x+1)} < l_x$, $p_x < 1$ and $\log p_x$ would be negative. To obtain a positive function we take the colog, thus

$$\operatorname{colog} p_x = (1-c)c^x \log g$$

then

$$\log \operatorname{colog} p_x = x \log c + \log [(1-c) \log g]$$

and, changing constants, we have

$$\log \operatorname{colog} p_x = ax + b \ldots\ldots\ldots [4]$$

Since Equation [4] is linear in x, p_x will plot as a straight line on graph paper whose ordinates are proportioned to log colog px.

This special graph paper has been designed for an ordinate range of p_x between 0.1000 and 0.9999, an interval which will usually include all of the observed data. The abscissas are uniformly spaced and their values may be changed to any convenient set. The utility of this graph paper is limited to those phenomena which follow the Gompertz law, a rather large class, with observational data sufficiently comprehensive to yield fairly stable mortality ratios.

Equation [4] may, evidently, be fitted to observational data by the method of least squares. This process, however, requires the use of appropriate weights since the residua are measured on a log-colog scale. The computations thus become onerous. A satisfactory graphical solution can be obtained in cases where log-colog graph paper may be used.

In the log-colog graph paper, the spacing of the ordinates appears to have a minimum between 0.300 and 0.400. That this is theoretically true may be checked by equating to zero the second derivative of Equation [4] with respect to p and solving for p, which will be found to equal 0.368.

J. F. Brennan.[2]

[1] The statements published herewith are those of the author and are not to be construed as official views of the Navy Department.

[2] Lieutenant, U.S.N.R., San Francisco, Calif.

Effect of Screw Threads on Fatigue

Comment by R. G. Sturm[3]

THE author of this paper[4] is to be congratulated on amassing an impressive bibliography dealing with fatigue with particular emphasis on screw threads. From these articles he gleans a number of suggestions for improving fatigue strength of threaded materials.

A number of the papers listed in the bibliography refer to the effect of the mean stress upon the stress range to which a material can be subjected for a given number of cycles without failure. The general conclusion drawn is that if a high mean stress is applied to the material the allowable stress range is appreciably reduced. The reverse may also be concluded, that is, the smaller the stress range the higher the allowable mean stress can be.

Most threaded connections hold parts together against a separating force so that if the bolts or studs are tightened sufficiently the parts will not separate. For these conditions it is possible to tighten the bolts or stud sufficiently so that when the parts are unloaded the stress in the bolt or stud is only slightly less than the stress existing when the parts are loaded. Under such conditions when the parts are loaded the stress in the bolt may be only slightly greater than if the bolt were not prestressed. Considerable advantage has been obtained by properly prestressing large tie bolts in presses and other heavy machinery. Prestressing, while increasing the maximum stress slightly, also increases the mean stress, cutting down the range of stress to an extent that even though the mean stress is high the fatigue life is materially increased. While this has not been concluded specifically by the author it does represent a practical fabrication procedure which may have as great an effect as any of the other post-manufacturing processes mentioned by the author.

[3] Research Engineer Physicist, Aluminum Research Laboratories, Aluminum Company of America, New Kensington, Pa. Mem. A.S.M.E.

[4] "Effect of Screw Threads on Fatigue," by S. M. Arnold, Mechanical Engineering, July, 1943, pp. 497–505.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

The Second Hydraulics Conference

REVIEWED BY E. B. STROWGER[1]

PROCEEDINGS OF THE SECOND HYDRAULICS CONFERENCE, June 1–4, 1942. Edited by J. W. Howe and Hunter Rouse. Published by the State University of Iowa, Iowa City, Iowa, 1943, Bulletin 27, No. 400. Paper, 6 × 9¼ in., 352 pp., 167 figs., $1.65.

IN June, 1942, the Iowa Institute of Hydraulic Research held its Second Hydraulics Conference under the sponsorship of the American Society of Civil Engineers, The American Society of Mechanical Engineers, and the Society for the Promotion of Engineering Education.

The First Hydraulics Conference, which was held in 1939, summarized current practice in certain phases of hydraulic engineering and the Second Conference dealt with the fundamental mechanics of fluid motion in engineering fields which have to do with either gaseous or liquid flow. Particular stress was placed on the astonishing similarity of principles utilized by the wide variety of professions dealing with fluid motion. The Proceedings of the Second Conference contains twenty-four papers dealing with the fundamentals of Fluid Mechanics. The twenty-seven authors have been well chosen as they are authoritative in the field of hydraulics, or as we should more properly say fluid mechanics. The papers have been classified by the editors into seven major phases of practical hydraulics, namely:

1 Scope and Importance of Fluid Mechanics.
2 Modern Methods of Research.
3 Mechanics of Fluid Resistance.
4 Cavitation Phenomena.
5 Problems of Wave Motion.
6 Engineering Aspects of Fluid Turbulence.
7 Sediment Transportation.

The first subject is covered in a stimulating manner by two outstanding authorities, Bakhmeteff and von Kármán. They lay the foundation for the rebuilding of hydraulics on a more scientific basis than that used to date. Von Kármán discusses particularly the problems of fluid mechanics which are suggested or emphasized by the needs of the war effort.

Tiffany, Baier, Kuethe, and Lane disclose many developments in laboratory technique and apparatus, contribute to the theory of similitude and the applications thereof, and discuss the general principles of towing-tank and wind-tunnel research.

The mechanics of fluid resistance as discussed by Munk, Rouse, Babbitt and Caldwell, and Muskat covers hydraulic shape resistance, the resistance in turbulent flow past smooth and rough boundaries, the flow of solid-liquid mixtures and flow through porous media. One very practical contribution in this series of papers is Professor Rouse's proposed resistance diagram for commercial pipe.

The papers on cavitation phenomena are written by three authorities in this field, namely, Mousson, Wislicenus, and Thomas. Mousson makes some important suggestions on the design of hydraulic turbines including a recommended profile for blade noses. Wislicenus shows the uniformity and completeness of the theory developed for pump cavitation and discusses similarity considerations. Thomas describes the technique used in testing model baffle piers at the bases of dams for cavitation and draws some important conclusions.

Mason, Posey, Wexler, and Ippen contribute to the subject of wave motion. Mason describes the experimental work which has been done in nature and in the laboratory and discusses the apparatus and techniques used. Posey formulates a general expression for discharge in unsteady flow and shows how to use it in problems of flood routing. Wexler discusses wave motions in the atmosphere and their importance in the forecasting of weather, and Ippen treats problems involving supercritical flow and the design of high velocity structures.

The engineering aspects of fluid turbulence is discussed by Kalinske, particularly in reference to river hydraulics. Thornthwaite discusses atmospheric turbulence and indicates that an understanding of this problem is prerequisite to a correct measurement of evaporation. Knapp makes additional contributions to the subject by discussing the mixing characteristics of density currents and their effect on the general turbulence of the fluid.

The last series of papers in the book deal with sediment transportation. In this series Camp takes up the effect of turbulence in retarding settling; Krumbein discusses the characteristics of sedimentary particles; Einstein shows how to calculate the bedload transportation in a natural stream, and the joint paper by Landsberg and Riley presents the study of the transportation of sand over a particular sand dune.

Each article in the book is quite complete with a list of references. The volume is therefore not only interesting and useful to the hydraulic engineer and the student of hydraulics but also to engineers in other fields who may encounter problems involving movements of liquids or gases or movements of objects in these media.

[1] Hydraulic Engineer, Buffalo, Niagara & Eastern Power Corporation, Buffalo, N. Y. Mem. A.S.M.E.; Chairman, Hydraulic Division.

Proceedings of Fifteenth Semi-Annual Eastern Photoelasticity Conference

PROCEEDINGS OF FIFTEENTH SEMI-ANNUAL EASTERN PHOTOELASTICITY CONFERENCE. Edited by W. M. Murray, Massachusetts Institute of Technology. Published by Addison-Wesley Press, Inc., Cambridge, Mass. Paper, 8½ × 11 in., 73 pp., illus., $1.50.

REVIEWED BY M. HETÉNYI[2]

IN the series of the photoelastic proceedings this volume is the third one edited by Professor Murray, bringing valuable contributions to the literature on experimental stress analysis. In accordance with the tradition of photoelasticity conferences, the seven papers contained in the present collection discuss many intricacies of experimental technique which would be difficult to find elsewhere.

Means of determining the complete state of stress within the boundaries of plane models are discussed by two papers. The first one, by Grosser, is of theoretical novelty and proposes to obtain the solution by way of a "shear membrane," a model of which, and its use, is demonstrated in the paper. The second

[2] Mechanics Department, Research Laboratories, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

paper, by Polivka and Eberhart, advances an improved method of graphical integration and illustrates its application by the detailed solution of a plane problem.

There are two papers on three-dimensional analysis. The first of these, by Meriam, is an application of the stress-freezing method to a problem of great interest: the distribution of centrifugal stresses in a supercharger impeller, and gives a detailed description of various stages in the test. The second one, by Frigon, contains studies by the scattered-light method, the technique of which still seems to desire much improvement.

A new method of stress analysis, whereby boundary stress values in plane models can be determined from the principal stress lines, is investigated by Durelli, using brittle lacquer coating on bakelite models, thus obtaining the stress trajectories with great accuracy. A general solution of deriving three-dimensional corrections to certain plane problems is advanced by E. Reissner. Application of this method to practical problems is anticipated with much interest.

In the field of material research, the paper by Leaf brings new results of his original investigations regarding the cause of "edge stresses" in photoelastic models. These stresses appear to be sensitive indicators of the moisture absorption and stability of synthetic resins, and the photoelastic method of determining these important material characteristics will probably be of great interest to research men in the plastics industry.

Industrial Safety

INDUSTRIAL SAFETY. Edited by R. P. Blake. Prentice-Hall, Inc., New York, N. Y., 1943. Cloth, 6 × 9 in., 435 pp., illus., $5.

REVIEWED BY HENRY G. LAMB[3]

THIS book is written in the style of a textbook and gives a broad and all-inclusive picture of the fundamentals of industrial-accident prevention. It should be valuable as text material in any formal course of education on this subject, or for the purpose of self-instruction by anyone who is about to assume duties in the safety field. It also has value as a reference work for safety engineers, both for the purpose of review of long-established fundamentals and because of its up-to-date information on the application of these fundamentals in the various subjects covered.

The thirty-one chapters of this book have been prepared by eight authors[4] who have had many years of practical experience in the prevention of industrial injuries. In this one book they present the combined viewpoints of safety engineers in a single large plant, the widespread organization of a public-utility system, a large casualty insurance company—covering both large and small plants in all branches of industry and all parts of the country, and in a governmental department concerned with the development of mandatory regulations as well as the distribution of educational material. The chapter on industrial health hazards has been written by public-health officers who are familiar with occupational disease problems and the work of the industrial hygienist.

The first part of the book gives an explanation of the importance of safety and its close relation to other production and personnel problems. Other sections deal with the problems of plant inspection, housekeeping, machine guarding, and educational and promotion activities. There is a detailed discussion of the various duties and responsibilities of the safety engineer and his relation to the heads of other departments in typical industrial organizations. There is also a description of the procedures of the American Standards Association and the role of American Safety Standards in the field of accident prevention.

The experienced safety engineer will undoubtedly be faced with many detailed problems which are not answered in this book. This is necessarily so, because of the wide variety of the problems covered and because the primary purpose of this book is for the instruction of those who are interested in the fundamentals and broad over-all aspects of the subject.

The first Engineering, Science and Management War Training Courses in safety engineering were started in January, 1941, by the University of Pennsylvania. At that time there were so few textbooks available on this subject that arrangements were made to reproduce copies of the first edition of "Industrial Accident Prevention" by H. W. Heinrich, published in 1931, for the use of these classes. Within the year, a second edition of this book including the advances of the past ten years, was published and has been used by subsequent classes. Now Mr. Blake's book will provide a welcome addition to this specialized field of technical information.

[3] Safety Engineer, American Standards Association, New York, N. Y.

[4] T. O. Armstrong, manager, Industrial Relations, Westinghouse Electric & Manufacturing Company; Roland P. Blake, senior safety engineer, Division of Labor Standards, U. S. Department of Labor; J. J. Bloomfield, sanitary engineer, U. S. Public Health Service; C. B. Boulet, director of personnel, Wisconsin Public Service Corporation; M. A. Gimbel, safety engineer, General Electric Co., Philadelphia Works; S. W. Homan, safety engineer, Children's Bureau, U. S. Department of Labor; W. Dean Keefer, second vice-president, Lumberman's Mutual Casualty Co.; R. T. Page, assistant sanitary engineer, U. S. Public Health Service.

Management of Manpower

MANAGEMENT OF MANPOWER. By Asa S. Knowles and Robert D. Thomson. The Macmillan Co., New York, N. Y., 1943. Cloth, 5¾ × 8¼ in., 248 pp., illus., $2.25.

REVIEWED BY J. M. JURAN[5]

THIS textbook is part of a more complete volume on industrial management and is intended to provide instruction for lower-level supervision and technicians in the day-to day problems of personnel management. For the most, the context follows usual practice for such textbooks, but with a better than usual level of presentation.

The discussion of organization and morale evidences much of the characteristic vigor and lucidity which we have learned to expect from Dean Knowles. The various techniques of personnel administration are treated in a practical vein and reflect a shop background as well as academic learning on the part of the authors. The book also propounds a number of very well-chosen and interesting problems for solution by students.

As is usual and safe, the book virtually ignores such unsettled problems as labor union participation, government regulation, and race discrimination. These are day-to-day problems for the foreman quite as much as for the top executive. It must be said, in fairness, that Knowles and Thomson do not shut their eyes to these problems any tighter than do other writers. We merely observe that many eyes are shut.

[5] Assistant Administrator, Office of Lend-Lease Administration, Washington, D. C. Mem. A.S.M.E.

Books Received in Library

AIR CONDITIONING ANALYSIS with Psychrometric Charts and Tables. By W. Goodman. Macmillan Company, New York, N. Y., 1943. Cloth, 6 × 9½ in., 455 pp., diagrams, charts, tables, $6. The aim here is to present a comprehensive, unified treatment of the fundamentals of the art of changing the condition of air, without discussing such related subjects as refrigeration, air handling, and temperature control. The material presented is developed from an elementary point of view and illustrated by numerous solved problems. Psychrometric charts with co-ordinates of enthalpy and specific humidity for a wide range of temperatures are included.

AIRCRAFT PROPELLER HANDBOOK. By K. H. Falk. Revised edition. Ronald Press Co., New York, N. Y., 1943. Cloth, 6 × 9 in., 146 pp., diagrams, charts, tables, $4.50. The aim of this work is to provide engineers, drafts-

men, and others in the aeronautics industry with a concise, practical discussion of propeller-design. The information is presented in simple form, with as little advanced mathematics as possible, and a minimum of theoretical discussion. The methods are illustrated by examples and a chapter on propeller selection is included.

AIRCRAFT YEAR BOOK for 1943, 25th Annual Edition, Howard Mingos, editor. Aeronautical Chamber of Commerce of America, Washington, D. C.; distributors, Lanciar Publishers, New York, N. Y., 1943. Cloth, $5^1/_2 \times 9$ in., 728 pp., illus., diagrams, charts, tables. As in previous editions this 1943 publication presents a record of events and developments in the aviation field during the past year. It covers the war in the air, the U. S. Army and Navy air forces, the Civil Air Patrol, air force training, governmental activities, and the air lines in war transport. The latter part of the book is devoted to aircraft designs, directories of manufacturers in the field, and statistical information.

AIRPLANE STRUCTURES, Vol. 2. By A. S. Niles and J. S. Newell. Third edition. John Wiley & Sons, Inc., New York, N. Y., and London, England, 1943. Cloth, $6 \times 9^1/_2$ in., 439 pp., diagrams, charts, tables, $4.50. Chapter topics of this revised edition are as follows: statically indeterminate stresses, analysis of beams having incomplete tension-field webs, computation of shear flow in thin shells (monocoque construction), determination of stresses in curved beams and rings; basic methods for dealing with beam and truss stability, an application of the calculus of variations to the torsion-bending stability problem in open-section columns. Allowable stress data and characteristics of some of the newer materials havebeen added and a critical bibliography is included.

AIRPORT CONSTRUCTION & OPERATION REFERENCE, 1943–1944 Annual Edition. Occidental Publishing Co., Los Angeles, San Francisco, Calif., and New York, N. Y., March, 1943. Cardboard, 9×12 in., 96 pp., illus., diagrams, tables, $2. In the text of this book the subjects of airport design, seaplane bases, war airfields, airport surfaces, buildings, lighting, communications and traffic control are presented by useful summaries of practice. In addition there is a buyer's directory of airport-equipment manufacturers and a directory of associations and agencies.

AMAZING PETROLEUM INDUSTRY. By V. A. Kalichevsky. Reinhold Publishing Corp., New York, N. Y., 1943. Cloth, $5 \times 7^1/_2$ in., 234 pp., illus., diagrams, tables, $2.25. This little book is a brief popular outline of the existing petroleum-manufacturing processes. What petroleum is, how it is obtained and transported, and how it is transformed into useful products are told clearly in language that laymen can understand.

ANALYTIC GEOMETRY. By E. S. Smith, M. Salkover, and H. K. Justice. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1943. Cloth, $6 \times 9^1/_2$ in., 298 pp., diagrams, tables, $2.50. A college text which aims to adjust the student to the new type of reasoning that analytic geometry calls for, by providing accurate, fully illustrated explanations of the topics commonly taught in that subject.

BLUEPRINT READING for the SHIPBUILDING TRADES. By A. E. Niederhoff. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, 8×11 in., 87 pp., illus., diagrams, charts, tables, $2. The fundamentals of blueprint reading necessary for the shipbuilding trades are covered in a simple and concrete manner. Orthographic projection, alphabet of lines, symbols, abbreviations, and ship terms are included. Actual prints used in shipyards mainly for Liberty Ship construction are used as examples.

(The) CHEMICAL BACKGROUND for ENGINE RESEARCH. (Frontiers in Chemistry, Vol. 2.) edited by R. E. Burk and O. Grummitt. Interscience Publishers, Inc., New York, N. Y., 1943. Cloth, $6 \times 9^1/_2$ in., 297 pp., illus., diagrams, charts, tables, $3.50. This volume presents a series of lectures by authorities within the field indicated by the title. Individual lecture topics are: a survey of combustion research, chemical thermodynamics of hydrocarbons, synthetic methods for hydrocarbons, kinetics of flame and combustion, the experimental side of combustion research in engines, and some physiochemical aspects of lubrication.

(The) CHEMISTRY of LARGE MOLECULES. (Frontiers in Chemistry, Vol. 1.) edited by R. E. Burk and O. Grummitt. Interscience Publishers, New York, N. Y., 1943. Cloth, $6 \times 9^1/_2$ in., 313 pp., illus., diagrams, charts, tables, $3.50. A series of lectures by authorities within the field indicated by the title is presented here in book form. Individual lectures cover the mechanism of polyreactions, various investigations of high polymers, colloidal behavior, ultracentrifuge applications, elastic-viscous properties of matter, and the chemistry of cellulose and its derivatives.

DAVISON'S RAYON AND SILK TRADES, including Nylon and Other Synthetic Textiles. The Standard GUIDE, forty-eighth annual, 1943 pocket edition. Davison Publishing Co., Ridgewood, New Jersey. Cloth, $7^1/_2 \times 5$ in., 402 pp., maps, tables, $5.50. A directory of manufacturers of silk, rayon, and synthetic textiles, and of dyers, finishers, agents, and others connected with these trades. The mills are classed geographically and also by products, with information as to capacity, officers, etc.

DIFFERENTIAL EQUATIONS. By H. W. Reddick. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1943. Cloth, $5^1/_2 \times 9$ in., 245 pp., diagrams, tables, $2.50. A textbook dealing with methods of solving ordinary differential equations and with problems in applied mathematics involving them. Partial-differential equations are not treated. The book is intended for both engineering and liberal-arts schools.

ECONOMY LOADING OF POWER PLANTS AND ELECTRIC SYSTEMS. By M. J. Steinberg and T. H. Smith. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1943. Cloth, $6 \times 9^1/_2$ in., 203 pp., illus., diagrams, charts, tables, $3.50. The problem of allocation of load to power plants and to the equipment within them so as to produce electricity at the lowest cost consistent with continuity of service has become important as large electric systems have been interconnected. In this book the problem is discussed in detail. The underlying theory of economy loading is explained, the mathematical conditions for obtaining maximum efficiency are derived, the application of incremental rates for the solution of load-division problems is set forth, the limitations in the application of the theory are discussed, and the practical solution of load-division problems is explained. There is a bibliography.

ENGINEERING DRAWING PROBLEMS. By I. N. Carter and H. L. Thompson. International Textbook Company, Scranton, Pa., 1943. Stiff paper, $8^1/_2 \times 12$ in., 142 plates, diagrams, charts, tables, $2.25. A carefully selected group of drafting exercises is presented, designed to be used with the text, "Engineering Drawing—Practice and Theory," by the same authors. In addition to the problem plates already made up, there are several blank plates for special work, and a number of sheets of tracing paper are provided for tracing practice.

FLUID MECHANICS. By R. C. Binder. Prentice-Hall, Inc., New York, N. Y., 1943. Cloth, $6 \times 9^1/_2$ in., 307 pp., illus., diagrams, charts, tables, $5. The aim of this book is to present the fundamentals of fluid mechanics. Both liquids and gases are dealt with, and the general cases of flow in pipes and in open channels are considered. The general arrangement is logical, beginning with statics, then kinematics, then dynamics which receives the fullest treatment. Applications to such practical subjects as lubrication and pumping are discussed.

INDUSTRIAL RADIOLOGY, X-RAYS AND GAMMA RAYS. By A. St. John and H. R. Isenburger. Second edition. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1943. Cloth, $6 \times 9^1/_2$ in., 298 pp., illus., diagrams, charts, tables, $4. This book is intended to furnish, in readable form, authoritative information on the practical use of radiology in industry. The general principles governing the production and use of X rays and gamma rays are presented, together with the techniques suitable for important classes of industrial materials. A bibliography of over 1300 titles is a valuable addition to the book.

MACHINE SHOP YEARBOOK AND PRODUCTION ENGINEERS' MANUAL. Second edition. Edited by H. C. Town. Paul Elek (Publishers) Ltd., Africa House, Kingsway, London, England, W.C.2, 1943. Cloth, $5^1/_2 \times 8^1/_2$ in., 497 pp., illus., diagrams, charts, tables, 30s 10d or abroad 31s 6d. Late developments in production, management, and design are here presented in convenient form for reference and study. Four special articles are included, on electrical control gear for machine tools, on optical instruments in engineering, on centerless grinding, and on the direct hydraulic system. Machine-tool construction and operation are discussed at length, with descriptions of representative British machine tools. The periodical literature of 1942 is represented by abridged articles of important publications on production and shopwork.

MANUAL of A.S.T.M. STANDARDS on REFRACTORY MATERIALS. Prepared by A.S.T.M. Committee C-8 on Refractories. American Society for Testing Materials, Philadelphia, Pa., June 1943. Paper, 6×9 in., 201 pp., illus., diagrams, charts, tables, $1.50; cloth, $1.75. Designed to give all of the A.S.T.M. standards on refractory materials—specifications, methods of physical tests, chemical analysis, and definitions—this extensively revised and enlarged publication also includes pertinent data developed by the committee and gives other supplementary information of service to those concerned with refractories.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

War Problems Discussed at Joint E.I.C. A.S.M.E. Meeting, Toronto

Eight Hundred Engineers Take Part in Meeting Sept. 30–Oct. 2, at Which General McNaughton and W. L. Batt Are Honored

IN many respects the joint meeting of The Engineering Institute of Canada and The American Society of Mechanical Engineers, which was held at the Royal York Hotel, Toronto, Ontario, September 30 to October 2, was a unique experience for the 800 members of the two societies and their guests.

In the first place it was truly a joint meeting from the planning of the program to the participation of the audiences in discussion. The general plan provided for seven sessions, each devoted to a single subject of broad but vital interest, with at least two speakers at each session, one presenting the point of view of engineers in the United States and the other the Canadian view. The chairmen of the sessions and the two luncheons were drawn from both societies; and members of the councils of both societies dined informally together for the purpose of closer acquaintanceship and better understanding. As a joint meeting it demonstrated co-operation at its best and most fruitful level.

For members of the A.S.M.E. who are accustomed to, and frequently harassed by, several concurrent sessions, each demanding his attention, the single-session program was a novelty. There were, however, running in parallel with these sessions, seven round-table conferences of a semiconfidential character to which a limited number of persons were admitted by invitation.

Another unique feature was the ceremonies at the dinner on Friday evening of the conferring of honorary membership in The American Society of Mechanical Engineers on Lt. Gen. Andrew George Latta McNaughton, General Officer Commanding, Canadian Army Overseas, and president, National Research Council, Ottawa, Ontario; and honorary membership in The Engineering Institute of Canada on William Loren Batt, vice-president, War Production Board, Washington, D. C., president, SKF Industries, Philadelphia, Pa., and past-president of The American Society of Mechanical Engineers. Neither General McNaughton nor Mr. Batt was present and the certificates were received by Dean C. J. Mackenzie, for General McNaughton, and Robert M. Gates, for Mr. Batt.

WILLIAM LOREN BATT, PAST-PRESIDENT, A.S.M.E.
(Made Honorary Member, E.I.C.)

Plans for Publishing Papers

Because of the dual origin of the papers presented at the general sessions, it has been agreed that each society would publish those secured by it and as many of the others as it desires. Arrangements are being made whereby members of either society can obtain copies of the papers not printed in his own society's publication. Elsewhere in this issue will be found, the papers by E. G. Bailey, General E. E. MacMorland, J. T. Bain, Howard Coonley, Charles E. Wilson, and Ralph E. Flanders. Other papers provided by the A.S.M.E. will be found in later issues. As soon as the entire group of papers is ready for distribution, an announcement concerning them will be made.

Bailey Discusses Steam Generation

The opening session on Thursday morning was devoted to a discussion of steam generation for marine and stationary service over the past decade and its effects on the war effort. A. G. Christie, past-president, A.S.M.E., professor of mechanical engineering, The Johns Hopkins University, Baltimore, Md., presided, and the principal paper, which covered developments and practices in the United States, was presented by E. G. Bailey, member A.S.M.E., vice-president of the Babcock and Wilcox Company, New York, N. Y. Mr. Bailey's paper, which will be found in this issue of MECHANICAL ENGINEERING, evoked considerable discussion, including comment by Engineering Admiral G. L. Stevens, of the Royal Canadian Navy.

LIEUTENANT GENERAL ANDREW GEORGE LATTA MCNAUGHTON
(Made Honorary Member, A.S.M.E.)

General MacMorland Speaks at Luncheon

C. R. Young, past-president, The Engineering Institute of Canada, and dean of engineering, University of Toronto, Toronto, Ontario, presided at the luncheon on Thursday at which the speaker was Brigadier General E. E. MacMorland, deputy chief, Field Service Division, and head of Maintenance Division, Ordnance Department, U. S. Army. General MacMorland's address, "Weapon Maintenance in Battle," will be found elsewhere in this issue.

K. M. Cameron, president, The Engineering Institute of Canada, delivered a brief address of welcome, saying that the meeting was an evidence of the common desire of the engineers of Canada and the United States to work together, to exchange information, and to do their utmost not only to beat Hitler and all he stands for but to be ready, when that task was accomplished, to carry on in their place and sphere, and to meet their opportunities with even greater determination.

Professor A. G. Christie responded to Mr. Cameron's address of welcome on behalf of The American Society of Mechanical Engineers.

Rail and Air Transportation

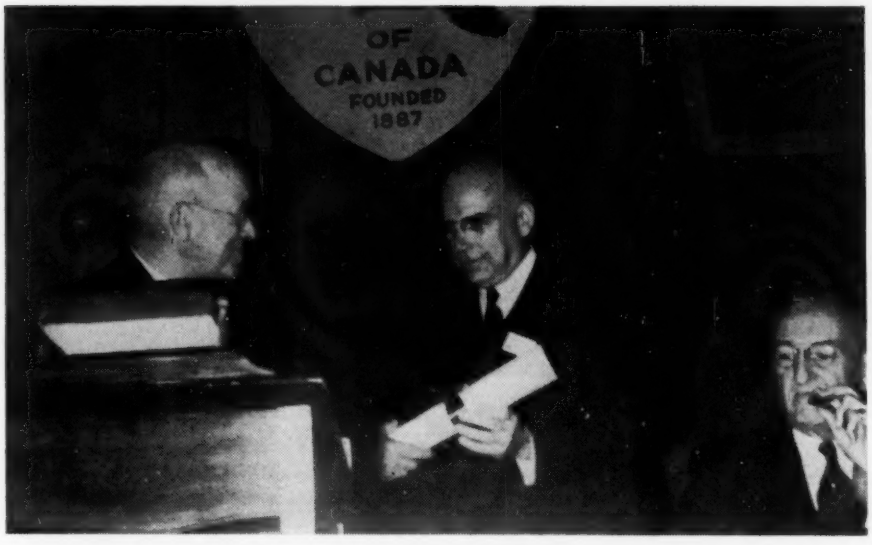
Transportation was the subject of the session on Thursday afternoon at which Lt. Com. C. P. Edwards, member, The Engineering Institute of Canada, and deputy minister, Department of Transportation, Ottawa, Ontario, presided.

Lawford H. Fry, fellow A.S.M.E., and director of research, The Locomotive Institute, New York, N. Y., presented a paper covering the railroad phases of transportation with particular reference to the locomotive and to developments and practices in the United States. The conditions being faced by Canadian railways during the war were described by F. L. C. Bond, member of The Engineering Institute of Canada, vice-president and general manager, Central Region, Canadian National Railways, Toronto, Ontario.

Owing to the illness of Edward Warner, member A.S.M.E., vice-chairman, U. S. Civil Aeronautics Board, Washington, D. C., who was to have spoken on air transportation, the subject was presented by Charles I. Stanton, chief administrator, Civil Aeronautics Administration, Washington, D. C. Mr. Stanton presented statistical estimates of postwar developments in air transportation that would link cities and towns of the United States together in an aerial network designed for convenience of travel.

A realistic view of what is in store for air transportation and a plea for greater attention to safety and ease of airplane maintenance was presented by J. T. Bain, superintendent of engineering and maintenance, Trans-Canada Air Lines, Winnepeg, Manitoba. Mr. Bain's paper will be found in this issue.

DE GASPE BEAUBIEN (HOLDING MICROPHONE) AND PROF. J. C. CAMERON (SEATED)



LEFT TO RIGHT: J. M. CAMERON, R. M. GATES, AND H. V. COES

(Mr. Cameron, president of the E.I.C., presents Mr. Batt's honorary membership certificate to Mr. Gates (acting for Mr. W. L. Batt), president-elect of the A.S.M.E., while Mr. Coes, president A.S.M.E., looks on.)

Airplanes of Wood Described

The session on Thursday evening, which in many ways was the most technical of the entire meeting, was devoted to production engineering and included papers on tank-hull construction, plastic plywood in aircraft construction, and the Mosquito airplane. A. R. Stevenson, Jr., manager, A.S.M.E., assistant to the vice-president in charge of engineering, General Electric Company, Schenectady, N. Y., presided at this session.

A comparison of riveting, casting, and welding of tank hulls was presented by L. E. Carr, technical director, British Ministry of Supply, Washington, D. C.

An extremely valuable technical paper, "Plastic Plywoods in Aircraft Construction," which discussed some of the fundamental features of this type of construction as developed in Canada, was presented by R. D. Hiscocks, engineer in charge of the structural laboratory, Aeronautical Division, Natural Research Council, Ottawa, Ontario.

With the aid of pictures showing the airplane in various stages of construction, R. B. McIntyre, project engineer, The de Havilland Aircraft of Canada, Limited, Toronto, Ontario, described the design features of the famous Mosquito airplane which is constructed principally of wood and is said to be the fastest operable airplane. Members of the two societies had been given an opportunity after luncheon that day to witness flights of two Mosquito bombers over the Toronto water front.

Conservation in U. S. and Canada

Steps taken in Canada and the United States to achieve conservation of materials through modification of design, substitution of less critical materials, and simplification were described at the general session on Friday morning. J. G. Notman, member, The Engineering Institute of Canada, and manager of manufacturing, Dominion Engineering Company, Montreal, Quebec, presided.

The Canadian experience was presented by C. B. Stenning, chairman, Conservation Committee, Department of Munitions and Supply, Ottawa, and chairman, Conservation Subcommittee, joint War Production Committee, United States and Canada. Mr. Stenning emphasized the cordial relations and fruitful cooperation between the two countries in interchanging materials and machines for war production.

Friday's luncheon was presided over by James W. Parker, past-president A.S.M.E., and executive vice-president, The Detroit Edison Company, Detroit, Mich. The address, "Canada's War Production," was delivered by H. J. Carmichael, co-ordinator of production, Department of Munitions and Supply, Ottawa, Ontario.

Manpower Utilization

Two of the most ably presented papers made up the program of the general session on Friday afternoon which was devoted to manpower utilization. A. C. Streamer, vice-president and assistant to the president, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., presided.

What had been accomplished, particularly in one Canadian industrial plant, to meet the problems of manpower, was described by A. L. Ainsworth, vice-president and general manager, John Inglis Company, Ltd., Toronto, Ontario.

From a more general point of view and with particular reference to conditions in the United States, Lawrence A. Appley, member A.S.M.E., and deputy director, War Manpower Commission, Washington, D. C., spoke on mobilization, utilization, and stabilization of manpower.

Three Able Papers on Postwar Planning

Postwar planning was the subject of the general session on Friday morning. William A. Hanley, past-president, A.S.M.E. and vice-president, Eli Lilly and Company, Indianapolis, Ind., presided.

A thoughtful paper along broad general lines, presented by Ralph E. Flanders, past-president, A.S.M.E., chairman, Committee on

AT THE PRODUCTION ENGINEERING SESSION

Research of the Committee on Economic Development, and president, Jones and Lamson Machine Company, Springfield, Vt., opened the group of three discussions. Mr. Flanders' paper appears elsewhere in this issue.

Some international aspects of postwar planning were discussed by W. A. Mackintosh, special assistant to the Deputy Minister of Finance, Ottawa; chairman, Joint Economic Committees (Canadian-United States); and vice-chairman, Advisory Committee on Economic Policy.

Speaking particularly on the subject of rehabilitation, already under way in Canada, W. A. Woods, Deputy Minister of Pensions and National Health, and vice-chairman, Advisory Committee on Demobilization and Rehabilitation, Ottawa, Ontario, included in his discussion the comments made to him during a visit to Great Britain by Canadian soldiers regarding what they hope to find when they return from the war.

At Friday's luncheon the chairman was de Gaspé Beaubien, past-vice-president, The Engineering Institute of Canada, and consulting engineer, Montreal, Quebec. The address, which was broadcast and which included a "code of ethics" covering labor relations, was delivered by Prof. J. C. Cameron, head of the Industrial Relations Section, School of Commerce and Administration, Queen's University, Kingston, Ontario. Professor Cameron's subject was "Trends in Industrial Relations."

Commonsense on Quality Control

The concluding session of the joint meeting was devoted to the subject of quality control. J. Manuele, director of quality control, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., presided and showed great skill in developing a lively discussion from the floor.

Andrew I. Peterson, member A.S.M.E., consulting engineer on quality control and professor of industrial engineering, College of Engineering, New York University, New York, N. Y., described in understandable language what engineers were trying to accomplish with the modern methods provided by this technique and gave many examples of successful application.

Some specific cases of the use of quality control were cited by H. H. Fairfield, metallurgist, Metallic Minerals Division, Bureau of Mines, Mines and Geology Branch, Department of Mines and Resources, Ottawa, Ontario.

During the discussion much evidence of the practical usefulness of quality control was brought forward by men who had had first-hand experience with it.

Round-Table Conferences

Running concurrently with the general sessions were several "closed" meetings of experts and interested engineers which constituted a series of round-table conferences.

JAMES W. PARKER, PAST-PRESIDENT, A.S.M.E., PRESIDES AT FRIDAY'S LUNCHEON
(The speaker at the luncheon, H. J. Carmichael, is at Mr. Parker's right.)

Admission to these sessions was by invitation only. The subjects discussed at these conferences were: Metal cutting, the use of modern steels in heavy industry, shell forgings, fuel substitutes, plastics, synthetic rubber, and powder metallurgy.

Through the kindness of representatives of several plants in the vicinity of Toronto, opportunity was afforded for the inspection of some important Canadian industries.

Charles E. Wilson Gives Banquet Address

Among the many evidences of friendly cooperation and kindred interest in a common cause and in the engineering profession, none was more impressive or enjoyable than the joint banquet on Friday evening which was attended by more than three hundred members and guests.

Serving as toastmaster on this occasion was C. J. Mackenzie, dean of engineering, University of Saskatchewan, Saskatoon, acting president, National Research Council, Ottawa, Ontario; and past-president of The Engineering Institute of Canada.

The principal address, "Production Paces the War," was delivered by Charles E. Wilson, member, A.S.M.E., executive vice-chairman War Production Board, Washington, D. C., and formerly, president, General Electric Company, Schenectady, N. Y. Mr. Wilson's address, which was broadcast by the Canadian Broadcasting Corporation, and which appears elsewhere in this issue, was warmly received.

J. B. Carswell, director, Department of Munitions and Supply (Canada), who had flown from Washington to Toronto with Mr. Wilson, was called upon to express the thanks of the audience for the address.

As already noted earlier in this report, the conferring of honorary memberships in The Engineering Institute of Canada and The American Society of Mechanical Engineers, was one of the pleasant and unique features of the joint meeting which will tend to bind the two engineering societies and the engineers comprising their respective memberships together.

General McNaughton Honored

In presenting the certificate of honorary membership in The American Society of Mechanical Engineers to Lieutenant General Andrew George Latta McNaughton, general officer commanding, Canadian Army Overseas and president, National Research Council

AT THE SPEAKER'S TABLE, SATURDAY LUNCHEON
(Right to left: A. H. Gorman, John E. Armstrong, George A. Stetson, W. A. Mackintosh, Ralph E. Flanders, and A. I. Peterson.)

Ottawa, Ontario, Harold V. Coes, president, The American Society of Mechanical Engineers, read the following letter from General McNaughton which was written in acceptance of the honor bestowed upon him.

Dear Mr. Coes:

Your letter of 24th August 1943 is very deeply appreciated, and I can assure you that it is a very high privilege indeed to have been elected an honorary member of The American Society of Mechanical Engineers. It is an added pleasure to learn that this great distinction is to be given me at a joint meeting of the American Society and the Canadian Institute in which I have been a member for many years, and that my membership will be received by my old friend Dean C. J. Mackenzie of the National Research Council of Canada.

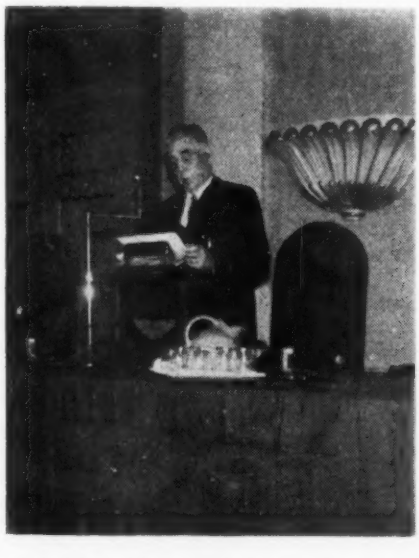
My recent visit to Sicily gave me the opportunity of seeing something of the work of engineers of both United States and Canada, and to examine the remarkable projects of reconstruction which they are undertaking, and particularly the effective application of power equipments, the design of which, as well as the development and manufacture, have come from the North American continent. These equipments are quickly overcoming the very formidable obstacles placed in our way by the enemy's considerable demolitions which were impeding seriously the advance of the forces of the Allies. Full credit must rest with members of The American Society of Mechanical Engineers for the development of these machines and for the many excellent motorized, mechanical, and amphibious equipments which were used there. A debt of gratitude is owed by all of us who have the duty of employing this equipment in the Armed Forces for the important contributions to the conduct of the war which members of the American Society have made already.

There is no doubt in our minds also that you will solve one of our key problems which is the transfer of large tonnage in landing operations across beaches. This will be a matter of very real and vital importance when the time comes for the attack on North-West Europe in the final advance upon the Capital and beyond.

Again let me express my deepest appreciation for the great honour which has been done to me, and with best wishes,

Very sincerely yours,

(*Signed*) A. G. L. McNAUGHTON



LAWFORD H. FRY READS HIS PAPER AT THE TRANSPORTATION SESSION

AT THE BANQUET

(Right to left: K. M. Cameron, President E.I.C., Dr. H. J. Cody, President University of Toronto, Air Vice-Marshal F. S. McGill, and W. H. McBryde.)

Batt Made Honorary Member E.I.C.

In conferring honorary membership in The Engineering Institute of Canada on William Loren Batt, past-president A.S.M.E., vice-president, War Production Board, Washington, D. C., and president, SKF Industries, Philadelphia, Pa., K. M. Cameron, president, The Engineering Institute of Canada, said:

A GROUP AT THURSDAY'S LUNCHEON

(Brigadier General E. E. MacMorland, speaker at luncheon, Col. George W. Beecroft, and Dean C. R. Young, who presided.)

In recognition of his eminence in the engineering sciences, The Engineering Institute of Canada, by a unanimous vote of its Council, has elected Mr. William L. Batt an honorary member of the Institute. Mr. Batt, a graduate of Purdue University, has been a member of The American Society of Mechanical Engineers since 1911, has taken an active and sustained interest in his profession through his work as member and chairman of committees of that Society of which he was vice-president for 1933 to 1935, and president in 1936.

In the broad field of industrial engineering, he is a director of several important manufacturing companies in the United States and has been president of SKF Industries since 1922.

Mr. Batt was elected vice-president of the Swedish Chamber of Commerce of the United States in 1926 and still holds that office. For his interest and activity in promoting commercial relations with Sweden, King Gustav of Sweden, in 1926, conferred upon Mr. Batt the decoration of the Order of Vasa and in 1933 the Royal Order of the North Star. In the further interest of good international business relations he served as chairman of the executive committee of the International Management Congress which met in Washington in September, 1938, and was elected president of the International Committee on Scientific Management to serve through the next triennial Congress to have been held in Stockholm, Sweden, in 1941, being the first American ever to be chosen for this international office.

Mr. Batt is chairman of the Business Advisory Council of the Department of Commerce, Washington, D. C., and is now on duty with the United States government, where he has served successfully as Deputy Commissioner, Industrial Materials Division, Advisory Commission to the Council on National Defense; Deputy Director of Production Division, Office of Production Management; member of Harriman Mission to Moscow in 1941 with temporary rank of Minister Plenipotentiary and Extraordinary; Director of Materials, Office of Production Management, and is now vice-chairman, War Production Board.

The "Edward Bok" Award was made to Mr. Batt on March 17, 1943, for his work on behalf of the war effort. He was honored by his alma mater, Purdue University, in 1933 with the degree of Doctor of Engineering, and the Stevens Institute of Technology conferred on him a similar degree in May, 1942.

Too much credit cannot be given to the secretarial staff of The Engineering Institute of Canada, L. Austin Wright, general secretary, and Louis Trudel, assistant general secretary, and Miss M. McLaren, for arrangements of program and hotel accommodations at Toronto in co-operation with the secretarial staff of The American Society of Mechanical Engineers.

The Local Joint Committee in charge of arrangements consisted of the following:

H. G. HILL, Junior Member A.S.M.E., chairman, Toronto, Section A.S.M.E.

W. H. M. LAUGHLIN, chairman, Toronto Branch, E.I.C.

H. H. ANGUS, Member A.S.M.E.

E. JONES, Junior Member A.S.M.E.

K. D. LEITCH, Member A.S.M.E.

F. TRUMAN, Junior Member A.S.M.E.

E. A. CROSS, Member E.I.C.

A. H. HALL, Member E.I.C.

C. F. MORRISON, Member E.I.C.

J. VAN WINKLE, Junior Member E.I.C.

Actions of A.S.M.E. Executive Committee

At Meeting in Toronto, Canada, on October 2

A MEETING of the Executive Committee of the Council of The American Society of of Mechanical Engineers, with other members the Council present, was held at the Royal York Hotel, Toronto, Ontario, Canada, on October 2 in connection with the joint meeting of The Engineering Institute of Canada and The American Society of Mechanical Engineers. Mr. Coes presided.

There were present, Harold V. Coes, president and chairman, Clarke Freeman, vice-chairman, George E. Hulse, Clair B. Peck, A. R. Stevenson, Jr., of the Executive Committee; A. G. Christie, William G. Christy, Fred V. Larkin, Warren H. McBryde, James W. Parker, Thomas E. Purcell, Albert E. White, and Walter J. Wohlenberg, of the Council; Robert M. Gates, president-elect; A. R. Mumford (Local Sections); and C. E. Davies, secretary. At the afternoon session there were also present: William A. Hanley, member of the Council; Ralph E. Flanders and Eugene W. O'Brien, former members of the Council; de Gaspé Beaubien, K. M. Cameron, and L. Austin Wright, representatives of The Engineering Institute of Canada. Ernest Hartford, executive assistant secretary, and D. C. A. Bosworth, comptroller of the Society, were present part of the time.

Elections

After action on various matters relating to Society finances the Committee declared the following elected to the fellow grade of membership: William Barton Edison, John P. Kottcamp, Harry A. Kuljian, Willits H. Sawyer, Herbert L. Seward, and A. C. Weigel.

The following were elected honorary members of the Society: Francis Blossom, New York, N. Y.; Ralph Budd, Chicago, Ill.; Lt. Gen. Andrew G. L. McNaughton, Ottawa, Ontario; Edward N. Trump, Syracuse, N. Y.; and Roy V. Wright, New York, N. Y.

Sundry Reports

It was reported:

(1) That the Engineering Societies Personnel Service, Inc., continued to operate without loss except for the Boston office.

(2) That the junior past-presidents of participating societies had been added to the membership of the Joint Conference Committee of Presidents and Secretaries.

(3) That a Joint Committee on Student Branches had been appointed by the Joint Conference Committee with Ernest Hartford as chairman; and that the committee had agreed on a general policy of encouraging students at institutions to meet in a single group during the period when educational programs of the schools were under general guidance of the Army and Navy.

(4) That a committee of three had been appointed by President Coes acting in his capacity of chairman of the Joint Conference Committee to develop questions and proposals about the organization of the engineering societies. (See the President's Page, MECHANICAL ENGINEERING, October, 1943, page 752.)

W.M.C. Consultative Committee

A report by R. E. Doherty, chairman of the Engineers' Council for Professional Development, was read. The report stated that steps had been taken to organize a Consultative Committee on Engineering to represent the engineering societies and act as an advisory group to the War Manpower Commission on engineering matters. The War Manpower Commission, Dr. Doherty reported, had accepted this proffer of an advisory group.

Professional Divisions

The Committee voted, on recommendation of the Committee on Professional Divisions, to establish the Consulting Engineering Group, to be organized in its new form by the present Special Committee on Consulting Practice.

The Committee voted, on recommendation of the Committee on Professional Divisions, to sponsor a Metals Engineering Handbook as suggested by the Metals Engineering Division.

Certificate of Appreciation

Approval was voted of a proposed certificate of appreciation for use by standing committees, their subcommittees, and local sections for recognition of substantial services. Each certificate is to have the approval of the Executive Committee of the Council.

E.C.P.D. and Local Groups

A procedure and policy for co-operation between local groups and the Engineers' Council for Professional Development was approved.

Awards

On recommendation of the Board of Honors and Awards the Committee approved the following awards for 1943:

Junior Award to Troels Warming, for his paper, "Power Pulsations Between Synchronous Generators."

Charles T. Main Award to Mitchell C. Kazen, for his paper, "Government as Affected by Engineering."

Undergraduate Student Award to William L. Hutton, for his paper, "The Aerodynamic Development of the Star Sail."

Meetings and Program

Approval of a resolution of thanks adopted at the Semi-Annual Meeting of the Sociey, Los Angeles, Calif., June 14–17, 1943, was voted.

Upon recommendation of the Committee on Meetings and Program the following Society meeting dates were approved:

1944 Spring Meeting, Birmingham, Ala., April 3–5.

1944 Semi-Annual Meeting, Pittsburgh, Pa., June 19–22.

Research Committee

Confirmation was voted by letter ballot approving a recommendation of the Research Committee to sponsor and organize a special research committee on demolition bomb bodies, to approve the personnel of the committee as nominated, and to approve a contract between the Society and the U. S. Army Ordnance for the conduct of the research.

Production Clinics

It was reported that P. T. Onderdonk was at present traveling among the local sections developing plans for Production Clinics during the current season. (See President's Page, MECHANICAL ENGINEERING, September, 1943, page 686.)

S.N.A.M.E. and A.S.H.&V.E. Jubilees

The Secretary was instructed to send greetings and best wishes to the Society of Naval Architects and Marine Engineers and the American Society of Heating and Ventilating Engineers on the occasions of their fiftieth anniversaries, November 11–13, 1943, and January 31–February 2, 1944, respectively.

"Mechanical Engineering" Sent to Military Libraries

It was reported that, beginning with the August, 1943, issue, complimentary copies of MECHANICAL ENGINEERING, to be sent to about 100 Air Force libraries, were added to the 52 complimentary copies already being sent to Army and Navy bases where qualified libraries are located.

Deaths

The Secretary reported the following deaths:

Conrad N. Lauer, past-president, August 2, 1943

James A. Seymour, honorary member, June 28, 1943

Albert Kingsburgy, honorary member, July 28, 1943

Conrad Matschoss, life member for distinguished service, March 21, 1942.

Appointments

The following appointments were reported:

Library Committee, E. F. Church, Jr.; Safety Committee, J. J. Zeitner (unexpired term of H. C. Houghton, 2 years); Economic Status of the Engineer Committee, Paul C. Hoffman, junior advisor; Special Research Committee on Strength of Vessels Under External Pressure, E. C. Korten, R. G. Sturm, and Dana Young; P. T. C. Committee No. 10 on Centrifugal Turbocompressors and Blowers, W. E. Johnson; Boiler Code Subcommittee on Rules for Inspection, D. L. Royer, chairman, T. B. Allardice, E. B. Van Sant, G. Walter, and W. H. Furman; U. E. T. Inc., George L. Knight; Research Procedure Committee, Engineering Foundation, W. Trinks; E.C.P.D. Ralph L. Goetzenberger (3 years); Guggenheim Medal Boardof Award, James M. Clark (3 years); Army Selective Service Office, Special Committee of Engineers, R. L. Sackett.

A.S.M.E. Calendar

of Coming Meetings

October 28–29, 1943
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Pittsburgh, Pa.

November 29–December 3, 1943
A.S.M.E. Annual Meeting
New York, N. Y.

April 3–5, 1944
A.S.M.E. Spring Meeting
Birmingham, Ala.

June 19–22, 1944
A.S.M.E. Semi-Annual Meeting
Pittsburgh, Pa.

(For coming meetings of other organizations see page 32 of the advertising section of this issue)

The President's Page

Function of A.S.M.E. in Management Development

IT IS indeed fortunate that the development of the technique of management has kept pace with technological progress in the United States, for if it had not done so, we would not have been able to turn out the vast quantities of materials which the prosecution of a global war demands.

The A.S.M.E. can take pride in the fact that the Society was farsighted enough to recognize the implications and possibilities of scientific management when this movement was in its infancy. It provided a forum for the presentation of the principles of management then being formulated. Papers which have become classics in the field of management were presented by engineers, many of whom were members of this Society, at meetings arranged by it.

One of our past-presidents has aptly stated that "engineers are thinking people." They are. They were able to distinguish between facts and opinions in this development of management technique. They experimented, made tests, and drew sound conclusions from the facts. We all know who were these pioneers who applied the engineering method of approach to the problems of management from which an alert and research-minded management resulted.

Take, for example, a panoramic view of the expansion of industry during a recent period. Expenditure for our war effort alone for 1943 will probably attain the tremendous total of $83,000,000,000. This is about equivalent to the total national income of 1929.

In 1900 the average work week was 56 hours. In 1939 it was 48 hours. During the same period total gainful employment increased 52 per cent. But in the manufacturing industries it increased 48 per cent, as the techniques of in-line and semi-in-line production were applied by engineers and management alert to the possibilities of low-cost production. For the same period factory production increased from $11,000,000,000 to $60,000,000,000, an increase of approximately 450 per cent as compared to a population increase of 60 per cent and a decline in the work week of slightly over 14 per cent. This was due largely to the application of mass-production principles and the multiplication of the horsepower made available to the factory worker.

Does anyone think that the production of $83,000,000,000's worth of war goods alone could be accomplished if management techniques had not been evolved which would permit the skillful administration of such a vast undertaking?

The same management principles, the same techniques, the same administrative skill are applicable to the solution of the problems which will be imposed on industry to satisfy the postwar demands for goods and services and for the gainful employment of the demobilized forces.

It is with respect to the foregoing that we engineers have a great responsibility. We must see to it that conversion from war products to peacetime products is rapidly and skillfully made, and that ingenuity is applied. Furthermore, the Society should take the lead in providing a forum for discussions of those principles which must be formulated and soundly and skillfully applied to the new postwar order in which we shall have to operate.

Some of the principles to be considered pertain to the changing relationship between industry and government and to the changing conditions within industry and labor. They must be applied to:

1 Recognizing that there are projects that industry cannot undertake because only government can finance and execute them for the public good.

2 Assisting in bringing about a clearer understanding of the functions and responsibility of government and industry in their respective spheres in our postwar economy and how to integrate them.

3 Assisting in bringing about a clear understanding of the social obligation of industry and the principles upon which this should be based. This would also involve a study of the amount, character, and type of government regulation required to attain the desired objectives and to protect those in industry who are honestly discharging their responsibilities from those who are not.

4 Giving serious consideration to exploring the train of events set in motion by technological development and evolving policies and a technique to reduce to the irreducible minimum the evils resulting from the blind application of it.

5 Assisting in the development and application of the basic principles of equitable industrial relations and in the development of the required techniques.

6 Taking an aggressive part in educating the public to a better understanding of the place of industry in our economy and of the real functions it performs.

7 Recognizing and dealing with the present evils in industry, airing them thoroughly, and stating the means for their elimination or correction and control.

I would like to see our professional divisions raise their sights and take for a target such a program as I have presented. I frankly think we have devoted too much time to the perfection of techniques in certain sectors of the management field and are overlooking some of the big problems that are or will be crying for a solution. As a result, the Society is not now, in my judgment, in forefront of the management movement.

I do not advocate that the Society should duplicate the work of such worth-while organizations as the American Management Association. Co-operation with the A.M.A. on some problems and independent action on other problems are in order. The Society should "pioneer" again, if you will.

Perhaps the work of the Management Division should be divided, broadly speaking, so that one group can go to work on the program I have discussed and the other follow the paths it has been pursuing.

I have been at work for some time on this message, and I believe it is one of the most important I have to present to you. I am firmly convinced that our Society has a real responsibility to discharge. It has done so in the past and I have faith it can do so again. It should blaze the trail for more rapid improvement in management through aiding in the solution of such important problems as I have enumerated.

(*Signed*) HAROLD V. COES, *President, A.S.M.E.*

Two and a Half Million Dollar Coal Research Program Approved

Twelve Major Research Investigations Contemplated Affecting Entire Annual Bituminous-Coal Production

PAVING the way for greater public benefits from the use of bituminous coal, such as fully-automatic home heating and summer cooling, smokeless stoves, gas from coal for the nation's pipe lines, radically improved railroad locomotives and chemical products, H. N. Eavenson, president of Bituminous Coal Research, Inc., has announced approval by the board of directors of a new five-year, $2,500,000 research program.

Determined to "do everything we can to give the public modern heating comforts and conveniences as well as the proved economy of coal," the directors of the bituminous industry's research agency followed recommendations of its Technical Advisory Board in reaching its decision in a meeting on September 10 at Battelle Memorial Institute, where an extensive program is already in progress. The announcement assures the continuation of the program started in 1935 by the coal operators to utilize the country's enormous coal reserves and thus to conserve declining reserves of oil and natural gas.

The half-million-dollar-a-year undertaking aims to rid the skies of coal smoke through complete combustion in apparatus ranging from small, smokeless, cabin heaters to large industrial furnaces. The principles have been demonstrated at the Battelle laboratories, where new forms of stoves, furnaces, and firing apparatus are taking shape to aid fuel utilization during the war and in the postwar future.

Twelve Major Research Investigations

Twelve major research investigations involving over ninety specific topics, and affecting the consumption of virtually the entire annual bituminous-coal production, are contemplated.

Cooling of residences in the summer by the same coal furnace that heats it in the winter, conversion of coal into gas without by-products, and household stokers that automatically take coal from the bin and put the ashes into containers are among the leading subjects scheduled for investigation. Coal-fired railroad locomotives which operate over longer distances without stops for fuel and water will be possible through improved combustion in radically new designs.

Coal-burning heaters and ranges that heat steadily all day and night without smoke and with only infrequent attention and one rekindling a season are to be perfected. To insure that stoves, stokers, and furnaces will meet with public satisfaction, high standards of performance will be sought through the adoption of rating codes and tests of these manufactured products. Chimney construction will be given attention to help architects eliminate faulty designs.

"Fluid coal," a suspension of finely pulverized coal that burns like gas in a hot furnace, is slated for further tests to enable coal to replace oil and gas in the furnaces of war factories where steel is now heated for forging and rolling in mighty presses. The same furnaces will someday soften steel for shaping into the implements of peace and commerce.

While finely pulverized coal has also been burned experimentally inside special "orange-hot" alloy-steel tubes, the commercial development of this high-temperature heating element for heat-treating furnaces will be undertaken as part of the new program. The particular advantage of indirect heating in this manner lies in keeping the gases of combustion from the product being heated.

The research also includes experimentation with pulverized-coal-fired internal-combustion engines and gas turbines for the production of power and the propulsion of locomotives and ships. An investigation of coal as an ingredient in brick manufacture, synthetic-rubber production, and in agriculture will also be undertaken.

Ashes will be given a major share of attention in proposed studies of burning coal in industrial boiler furnaces. The ashes can often best be removed as fluid slag or partially fused solid pieces, but the principal difficulties to be overcome are the adherence of sintered and fused ash on the inside of the combustion furnaces and the escape of a small proportion to the atmosphere.

Production of Ash-Free Liquid

The main objective of a project on the production of chemicals from coal is the production of an ash-free liquid, probably by hydrogenation, which then could be processed by subsequent treatment to yield a variety of materials for various industries. Among the products to be obtained in this way would be tar acids, a basic ingredient for the plastic industry, and solvents. It is now known that by hydrogenation, coal yields at least ten times the quantity of tar acids that can otherwise be obtained from the same coal. No work has been done to determine the possible maximum yield and it is conceivable that the factor may be increased to 20 or 30.

Bituminous Coal Research, Inc., is the research organization of the bituminous-coal industry and is affiliated with the National Coal Association. Laboratory headquarters of Bituminous Coal Research are at Battelle Memorial Institute.

Yellott Heads Institute of Gas Technology

JOHN I. YELLOTT, member A.S.M.E., A.S.M.E. Junior Award 1934, Pi Tau Sigma Medalist, 1939, and recipient of Chicago and Illinois Junior Chamber of Commerce awards for distinguished service in 1942 for his educational training activities, has been appointed full-time director of the Institute of Gas Technology at Illinois Institute of Technology.

Yellott, who has been chairman of the department of mechanical engineering and director of war training at Illinois Tech, assumed the duties of his new position as of September 1. He succeeds Harold Vagtborg as director of the Gas Institute.

Established to provide a central research and educational service for the entire gas industry, the Institute of Gas Technology has expanded its educational, research, and library services to an annual budget of almost $200,000. The Gas Institute now has a fellowship group of 21 postgraduate students training for specialized technical service in the gas industry.

In addition, it has under way a number of research projects for its various member companies as well as several long-range fundamental research programs established for the general benefit of the entire gas industry.

1944 Officers of A.S.M.E. Elected by Letter Ballot

AS reported by the tellers of election Wm. H. Boehm, Theo. M. Knoop, and C. W. Obert, letter ballots received from members of The American Society of Mechanical Engineers were counted on Tuesday, Sept. 28, 1943. The total number of ballots cast was 4816; of these 149 were thrown out as defective.

Candidates	*Votes for*	*Votes against*
For President		
ROBERT M. GATES	4652	15
For Vice-Presidents		
RUDOLPH F. GAGG	4661	6
DAVID W. R. MORGAN	4662	5
JONATHAN A. NOYES	4660	7
FORD L. WILKINSON, JR.	4657	10
For Managers		
J. CALVIN BROWN	4662	5
ALTON C. CHICK	4647	20
SAMUEL H. GRAF	4657	10
JAMES M. ROBERT	4659	8

In addition to the votes cast for the elected directors, valid ballots were cast as follows: For president, 6 names; for vice-presidents, 8 names; and for managers, 11 names.

The new officers will be introduced and installed in office during the Sixty-Fourth Annual Meeting of the Society to be held in New York, N. Y., Nov. 29 to Dec. 3, 1943.

Biographical sketches of the newly elected officers appear in the August, 1943, issue of MECHANICAL ENGINEERING, pages 608–612.

Destroyer Escort Vessel Named in Honor of Junior Member

ON August 26, Mrs. Sanford Stadtfeld, widow of Lieutenant Sanford Stadtfeld, junior member A.S.M.E., who was killed in action aboard a heavy cruiser in the South Pacific on the night of November 30, 1942, attended the commissioning ceremonies of the destroyer escort vessel the U.S.S. *Stadtfeld*, named in honor of her husband.

Water Conference at Pittsburgh, Nov. 1 and 2

THE fourth Annual Water Conference of the Engineers Society of Western Pennsylvania will be held in the William Penn Hotel, Pittsburgh, Pa., on Monday and Tuesday, Nov. 1 and 2, 1943.

Among the Local Sections

Bridgeport Section Hears Chas. E. Williams

AT its first meeting of the 1943-1944 season, September 16, the Bridgeport Section enjoyed hearing Charles E. Williams, district passenger agent of the New York, Hew Haven & Hartford Railroad, describe the vital part railroads are playing in the war effort. In conjunction with this interesting talk a sound film was shown with Lowell Thomas as commentator. The film depicts the operation of steam and Diesel engines in use, and how railroads are meeting the burden imposed on them by the war. This Section highly recommends this film to all New England sections and elsewhere. The presiding officer of the meeting was Peter A. Ibold, chairman of the Local Section.

Denver Section Hears Metallurgist

The Denver Section held its meeting on September 16 at the Oxford Hotel. Wayne Parcel, metallurgist of the Denver & Rio Grande Western Railroad Company, spoke on "Physical Failures of Locomotive Parts." Mr. Parcel's talk was illustrated by lantern slides depicting various types of failures of locomotive parts and methods which are used in the laboratory in determining the causes of and procedures recommended to prevent reoccurrence.

Milwaukee Section Visits Shipyard

The Milwaukee Section made a guest tour through the Froemming Shipyard Shipbuilding Corporation on September 8. Guides escorted the group aboard each of the two styles of ships under construction. The seagoing tugs are equipped with de luxe appointments. Visitors were taken through the quarters of the captain, mate, and chief engineer. They also saw the galley, mess room, pilot house, gyro room, radio room, chart room, and the control instrument room as well as the main engine room which houses twin Diesels and auxiliary engines. Adjoining the main engine room is a completely equipped machine shop including electric repair quarters. The tugs are completely air-conditioned and carry the finest equipment. These boats are intended to assist disabled craft at sea. The party then went aboard a frigate to inspect the twin-screw steam engines as well as the refrigerating equipment. These boats are devoid of all luxuries. Bare necessities are provided, with ventilation furnished only through briederts which pass air in through the bulkheads and prevent water from entering. The group was then conducted about the yard to observe construction methods and equipment. Considering the emergency nature of equipment facilities, the accomplishments in ship production have been exceptional.

Southern California Enjoys Talk on Electronics

On September 9 the Southern California Section held a dinner meeting at the Clark Hotel, Los Angeles, Calif., after which E. W. Morris, engineer of the Westinghouse Electric & Manufacturing Co., discussed "Electronics at Work Today." Preceding Mr. Morris's talk, a sound film produced by the company was shown depicting the elementary functions of electronic tubes and various fields of other application. The fact that the subject matter was of interest to the assembled members was evidenced by the discussion and questions which followed the program.

Refrigeration Cycle Explained at Susquehanna Section

The Susquehanna Section met on October 4 at the Violet Hill Cafe in York, Pa., where R. L. Jones, appliance engineer of the York Corporation, spoke on the subject "The Absorption Refrigeration Cycle." He illustrated the gradual development of the absorption cycle from the original and conventional compress cycle using compressors and showed how with the absorption cycle machinery can be simplified by replacing compressors with centrifugal pumps.

Western Massachusetts Holds Dinner Meeting

On September 21 the Western Massachusetts Section held a dinner meeting at the Highland Hotel in Springfield, Mass., with 46 members and guests present at the dinner and 56 at the meeting which followed. Messrs. Sweetland, Maynard and Pringle, all from the Westinghouse Electric & Manufacturing Co., were introduced as new members. Mr. Peter J. Equi, who was in charge of arrangements for the evening, then introduced the speaker of the evening, M. P. Robinson of the Worthington Pump & Machinery Corporation, who spoke on "Evolution and Modern Practice of Boiler Feedwater Purification by the Hot Process." Mr. Robinson, with the use of lantern slides, traced procedures from 1881, when limestone was merely thrown into the water to be softened, up through the different stages of perfection covering the use of the lime-soda ash process, and the present deaerating type. He went into detail explaining the difficulties encountered, including backwashing the filters and keeping the lime agitated, and how these problems have been overcome, mentioning the different schemes in progression and the final improvements. In closing, he stated that while zero hardness was impractical, it is now possible to obtain a degree of 10 parts per million without too much trouble.

West Virginia Section Hears "Power by Wright"

On September 28 the West Virginia Section held a dinner in honor of H. E. Linsley of the Wright Aeronautical Corporation of Paterson, New Jersey. Mr. Linsley was the guest speaker of the evening and gave a very interesting lecture on "Power by Wright." He was a flying officer of the R.A.F. in World War I and has been connected with the airplane industry since that time, both in Europe and in America. He illustrated his talk with two moving pictures. One of the pictures showed the manufacture of the famous 1700-hp Wright Cyclone engine by following the procedure in the Paterson, N. J., plant from the foundry, after description of the experimental stage, down through the assembly, testing, and shipment of this engine. Many interesting methods peculiar to the airplane industry were shown as pertaining to this special type of mass production, precision, inspection, and so on. The interest of the one-hundred-odd persons attending the meeting was reflected in the fact that Mr. Linsley was kept busy answering questions.

R. G. McElwee to Address Metropolitan Junior Group, Nov. 23

Members of A.S.M.E. and A.F.S. Cordially Invited

MEMBERS of the A.S.M.E. and The American Foundryman's Association are invited by the Metropolitan Junior Group to attend a meeting on Nov. 23 to hear Mr. R. G. McElwee of Detroit, on "Gray Iron as an Engineering Material."

Mr. McElwee is manager of the Foundry Division of the Vanadium Corporation of

R. G. MCELWEE

America, and is also serving on the staff of the War Production Board, Forgings and Castings Unit, as well as on several technical committees. He has had wide experience in the operation of foundries and the production of castings from 1915 to the present. It will be a fine opportunity for engineers in and about New York to hear up-to-date facts on the ins and outs of that important fabrication method—casting.

The meeting is to be held in the second-floor dining room of Childs Restaurant, 109 W. 42nd St., at 7:30 p.m., preceded by an informal get-together at 6:00 and dinner at 6:30 to which all are invited. ($1.00 per person.) Those who cannot attend the dinner will be welcome at the meeting.

With the Student Branches

Triple Attraction at Purdue

PURDUE BRANCH held its first meeting of the fall semiterm on September 8. Prof. F. C. Hockema, member A.S.M.E., assistant to the president of the University, spoke to the group of old members and new prospects about some of the advantages which A.S.M.E. Student Branch membership offers.

The short talk was centered around Professor Hockema's "Decalogue:"

(1) The A.S.M.E. is a national organization with international renown. Your membership card is a pass to many a locked door.

(2) Later in life it is difficult to become an A.S.M.E. member. Student membership is handed to you practically on a silver platter and it facilitates later full membership; it also makes the initiation less expensive.

(3) All prominent mechanical engineers are members of the A.S.M.E.

(4) The A.S.M.E. journals keep you informed of recent progress and developments in your field.

(5) The A.S.M.E. journals provide an outlet for your writings.

(6) The A.S.M.E. supplies an excellent library service.

(7) The A.S.M.E. gives you an opportunity for campus activity, offices, and jobs.

(8) The A.S.M.E. maintains a good employment service.

(9) The A.S.M.E. provides for you interesting programs on campus and off.

(10) The A.S.M.E. keeps you on your toes for your future development and prevents the dreaded stagnation.

Each of these points was well illustrated with examples from the speaker's wide range of experience.

Films Shown

The second part of the program consisted of films. "Campus on the March" and "Negro Colleges at War" were shown. They depicted vividly the wartime scene in the nation's colleges and universities and the contribution of these institutions to the war effort in supplying mentally and physically trained men to the armed services, to industry, and to the laboratories. The films gave the student an insight into his part in the pattern of war.

Social Meeting

Last, but not least, was a social meeting with ice cream, informal conversation, and an opportunity to enter the Student Branch. Almost all newcomers took advantage of that opportunity to conclude a successful start of a new season.

A Yeoman Speaks at Purdue

On September 22 this Branch met to hear apprentice seaman Bill Harding, a V-12 student at Purdue who was formerly a yeoman serving on a submarine with the Asiatic fleet in the Pacific. Bill explained many of the general mechanical features of the present-day submarine, supplementing his discussion with a large sectional drawing of a submarine which he used as an aid in describing the various compartments. He then told of his experiences in enemy waters and gave his audience an excellent picture of life aboard one of Uncle Sam's modern submarines.

REFRESHMENTS AT PURDUE BRANCH WHERE ARMY, NAVY, AND MARINE PERSONNEL ARE INCLUDED IN THE MEMBERSHIP OF THIS BRANCH

Other Branch Meetings

THE ALABAMA POLY BRANCH met on October 5 and heard Prof. C. R. Hixon, member A.S.M.E., and head professor of the mechanical-engineering department speak on "The Value of A.S.M.E. to the Student and to the Engineer." Officers for the forthcoming year were elected and the newly elected president, Robert L. White, told the members present that he believed the Branch would take their meetings more seriously than in the past because of the national emergency.

The ARKANSAS BRANCH met on September 28 and heard Buron Owen discuss "Gas Turbines." He gave a brief history of the gas turbines, described operational principles, and brought out a few applications of the turbine. Plans were made for inspection trips to industries of a nearby city. Officers for the coming year are: Bob Duncan, president; Durbin Miller, vice-president; Harlan Holmes, secretary-treasurer; and honorary chairman, Prof. F. J. Daasch, member A.S.M.E.

The CALIFORNIA BRANCH held its second meeting on September 1. The secretary, Austin Sanderson, announced the receipt in bulk of the July and August, 1943, issues of MECHANICAL ENGINEERING. M. E. Murphy, honorary chairman, announced the possibility of obtaining past issues of the A.S.M.E. catalog and asked for a show of hands by those who desire a copy. The show of hands was unanimous. The speaker of the evening, W. H. Kassebohm, chairman of the San Francisco A.S.M.E. Local Section, director of the West Branch Tool Engineers, and plant manager of the Production Engineering Company of Berkeley, Calif., gave a vigorous and inspiring talk on "The Young Engineer and the Profession." Mr. Kassebohm stressed the opportunities present in the production field for a college-trained engineer.

CALIFORNIA TECH BRANCH heard an instructive lecture on "Polarized Light" by H. L. Doolittle, designing engineer, Southern California Edison Company, member A.S.M.E., on August 4. Preceding and following the meeting the purpose and advantages of the A.S.M.E. were explained to prospective members by Prof. R. L. Daugherty, honorary chairman of the Branch and past vice-president of the A.S.M.E., the new faculty adviser, and George Shor, branch chairman.

On September 1 CLARKSON TECH BRANCH met with 24 members and guests present. President A. R. Fales introduced Mr. Dunbar of the Massena Aluminum Company, who in turn introduced Mr. Campbell of the Campbell Institute of New York. Mr. Campbell gave an interesting talk on what he had observed in his contacts with people. He stated that the average person never developed his full capabilities and potentialities, and that some of the major hindrances to a person's success were fear, personality, and inability to get along with others. This Branch met again on September 15 when Dr. Alfred R. Powers of the electrical-engineering department, spoke on "The House of the Future." He stated that the house of the future will have no cellar that it will be made in sections so that it may be easily added to by enlarging the rooms, that the framework, doorways, and window frames will be made of aluminum or aluminum alloy and that the walls will be glass or plastic bricks. The windows will be of flexible glass, the partitions will be movable so that the size of the rooms may be increased or de-

APPLICANTS FOR MEMBERSHIP IN PURDUE BRANCH

creased as desired. The heating will be done by heating units built directly into the walls. Each room will be equipped with apparatus to remove dust, properly humidify, and sterilize the air. The lighting will be indirect fluorescent light that will resemble daylight. The furniture will be of aluminum or magnesium alloy. There will be no common stove. All cooking will be done by individual units. There will also be a quick-freeze unit for food storage.

The DETROIT BRANCH has made extensive plans for the 1943-1944 season. During the past year a twenty-five dollar prize was awarded John A. Mershcel at the regional meeting for his paper on "Powdered Metallurgy." Jack Z. Lance, former chairman of the student branch, was awarded a book for outstanding work in connection with the local Branch.

The DREXEL BRANCH introduced its new officers for the 1943–1944 year at its meeting on October 5. Plans were outlined by William Hoch, editor for a new branch newspaper called "The Exhaust." This will be printed monthly and will contain technical articles and mechanical-engineering news about Drexel. Prof. Wm. Stevens of the mechanical-engineering department, member of A.S.M.E., spoke briefly on the past achievements and activities on the value of the A.S.M.E. for engineers. The General Motors sound film, "The Diesel Modern Power," was shown. Also the members saw the film "The Construction of the Light Airplane," by the Piper Aircraft Corporation.

The Young Engineer in Industry

The ILLINOIS TECH BRANCH met on August 20 to hear Alexander D. Bailey, past vice-president of the A.S.M.E., assistant to vice president of Commonwealth Edison Company, guest speaker and feature attraction at this meeting. His subject was "The Young Engineer in Industry." He stated that industry is looking for men with common sense plus technical education. Industry wants men who show potentialities for future success, who can handle people, and who can lead and be followed. He reminded the audience of the survey made by Dr. Karl T. Compton, member A.S.M.E., president of M.I.T., who checked 50,000 company executives and officials. Dr. Compton found that the engineering-college graduates are 30 times more apt to find themselves in executive positions than the liberal-arts graduates.

KANSAS BRANCH met on September 1 at which time Prof. E. E. Ambrosius, member A.S.M.E., explained the purpose and advantages of belonging to the Student Branch of the A.S.M.E. He gave some points on the spring meeting held in Kansas City last spring and urged active participation of all members in the activities of the A.S.M.E., be it local or national. The new officers were introduced. Many members of the Navy V-12 unit were present, and plans for the spring meeting of next year were discussed.

On August 31 MICHIGAN MINING and TECH BRANCH heard honorary chairman, Prof. A. P. Young, member A.S.M.E., discuss the subject "Arc Welding." Following his talk, a film "Inside Arc Welding," was shown. In conclusion, Professor Young answered a few questions pertaining to this subject.

N.Y.U. BRANCH held its first smoker on August 25. Forty new members were accepted of which one half are at present in the A.S.T.U. The guest speaker, H. Linsley, a public relations officer of the Wright Aeronautical Corportion, showed two films—"Cyclone Combustion" and "Power by Wright." The latter describes the details of the manufacture of a Wright Cyclone 14-aircraft engine.

OHIO BRANCH held its last summer quarter meeting of the year on August 20, at which Dr. Avey, chairman of the philosophy department, gave an interesting talk on "Philosophy and Science."

Petroleum and Its Uses at Oregon Branch

The OREGON BRANCH met on September 3 with an attendance of 29 members, 15 student visitors, and 4 faculty members. In order to carry on the activities of the Branch between regular civilian school terms, election of officers from A.S.T.U. members was held, these officers to serve pro-tem, pending return of the civilian students. Harold Cookson was elected chairman, Charles Mach, vice-president, Joe Johnson, secretary, and R. W. Ely, treasurer. A Bureau of Mines film on "Petroleum and Its Uses" was shown starring Dick the interrogator, Uncle Gideon, who knew all about oil, and Gay, the walking oil well. General discussion was held regarding anticipated programs, films, and inspection trips. Plans were made to inspect a plywood plant in Albany on September 18.

Rensselaer Branch Hears Capt. G. S. Burrell

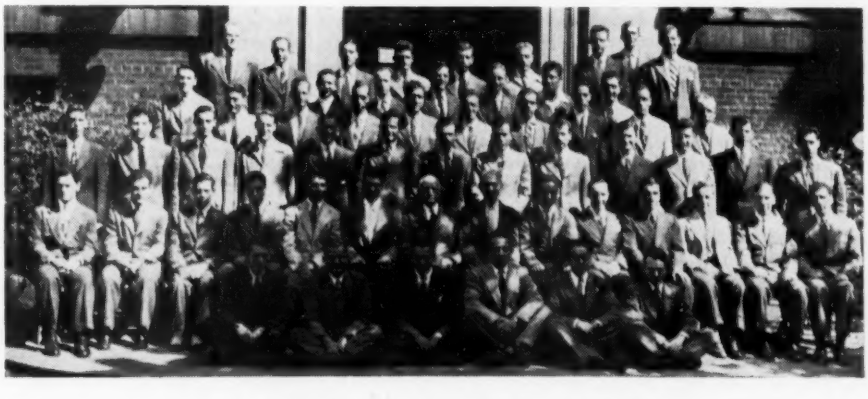
On September 1 RENSSELAER BRANCH held a meeting to hear Captain G. S. Burrell (CEC) U.S.N., speak on "Mechanical Engineering in the Navy." Captain Burrell pointed out during the course of his lecture the huge part played by the mechanical engineers and engineering design in the Navy. Captain Burrell served five years at Pearl Harbor, Hawaii, in the development of the Naval Base there, including all of the pioneering work. Later he spent a year on development work in Guam. More recently he has served as yard and district public-works officer of the Fifth, Sixth, and Eighth Naval Districts. He is the author of "Standards of Design for Structural Steel," which is used in the Bureau of Yards and Docks and at all shore stations. Since February, 1943, Captain Burrell has been in administrative charge of the Naval Officers pursuing postgraduate courses in civil engineering and ordnance engineering at Rensselaer Polytechnic Institute. He stated that there should be huge advance in marine engineering upon the advent of larger, more modern, and more powerful Diesel engines. Slides of modern warships, 15-story jib cranes, and power units were shown. Elections were held after the lecture with the selection of new officers, and Prof. Marsden A. Cook, member A.S.M.E., of the mechanical-engineering department, was re-elected as honorary chairman for another term of office.

This Branch met again on September 29 to hold its second regular meeting of the present semester. The features of the evening were two railroad movies which were sponsored by the joint A.S.M.E. and Rensselaer Central Railroad organizations of the mechanical-engineering department. One was "A Great Railroad at Work," from the N.Y.N.H. & H. Railroad. The other was a technicolor film entitled "Railroading," which was obtained from the General Electric Company.

On September 10 RUTGERS BRANCH met to hear a lecture on "Production Engineering and the War Effort," by Prof. C. L. Tutt, member, A.S.M.E., of Princeton University. Professor Tutt illustrated his talk with interesting slides. The lecture stimulated a worthwhile discussion, carried on while refreshments were served.

AT-6 Texas Advanced Trainer

On August 12 SOUTHERN METHODIST BRANCH held its opening meeting of the current school year with an attendance of 22 mechanical-engineering students and 3 faculty members. An informative talk on "Modern Manufacturing Processes in Use in War Plants" was given by Prof. N. P. Sherwood, junior member A.S.M.E. A discussion was held on future plans of operation of the Branch under new membership periods. This Branch met again on



SENIOR BRANCH A.S.M.E. MEMBERS AT PRATT INSTITUTE

SOME STUDENTS OF GROUP XVI ATTENDING A.S.M.E. STUDENT CONFERENCE IN SPOKANE, WASHINGTON, MAY 10, 1943

August 27 in the Fondren Library Auditorium when a film, furnished by North American Aviation, Inc., of Dallas, Texas, was shown on "The Building of the AT-6 Texas Advanced Trainer."

STEVENS INSTITUTE BRANCH met on September 14 to make plans for the season. This Branch has been more or less inactive because of the necessity of an organization and acclimatization period brought about by the school's entering into a contract with the Navy for the use of its facilities as a V-12 training station. Plans were made for a smoker to be held in October. A program committee was appointed. Honorary chairman, Prof. K. E. Moses, spoke of his hopes and plans for rebuilding the Branch into one of the leading organizations on the campus, as well as making it a credit to the parent organization.

Texas Branch Hears V. L. Doughtie on "History of Power"

The TEXAS BRANCH held four meetings during the summer term. A "get-acquainted" meeting was held on July 12. Chairman Frederick introduced the officers of the Branch and then presented Prof. V. L. Doughtie, member A.S.M.E., who explained the benefits and advantages of membership in the A.S.M.E. Prof. H. E. Degler, member A.S.M.E., chairman of the department of mechanical engineering, then introduced the faculty of that department, including Messrs. Bartlett, Benson, Besserer, Brown, Doughtie, Kent, Short, and Eckhardt. The second meeting took place on July 26 at which time Professor Eckhardt gave an interesting lecture on "The Early History of Power." This talk took the form of a series of biographical sketches of such men as Nero, Archimedes, da Vinci, Papin, and Watt. Professor Eckhardt preceded his biographies with a few slides showing the magnificence of some of our modern power-generator equipment. At their meeting of August 9 this branch, after an intensive publicity campaign ramrodded by vice-chairman McGinnis, brought forth a near-record attendance at this meeting. An estimated 115 men were present for a program of three movies "Building the B-26 Bomber;" "Mickey Mouse on the Flying Trapeze;" and "Modern Man-O-Warsmen." On August 23 the A.S.M.E. joined forces with the A.I.E.E. to hear talks given by Messrs. Wise and Uhr representing the General Electric Company.

On September 13 this branch met again and A. D. Payne, honorary chairman of the branch, gave a short talk directed at the student members and included several suggestions concerning ways and means of improving the operation of the Branch. He urged that as many students as possible prepare papers to be entered in the competition for the Chas. T. Main Award. Three films were shown: "The Life of Thomas A. Edison," "Science Facts," and "Railroading." This Branch met again on September 20 which was a joint meeting of the A.S.M.E. and A.I.E.E. Mr. Frank Rushing, the guest speaker of the evening, discussed "Balancing Rotating Machines."

TULANE BRANCH held its first meeting on July 23 at Stanley Thomas Hall at the university. Plans were made for inspection trips to several industries. Mr. Cuculla, chairman of the senior branch, then gave a brief, interesting talk on "What the A.S.M.E. Can Do and What It Is Doing for the Student." After this talk a film on "Steam Turbines" was shown.

VILLANOVA BRANCH met on August 18. Mr. J. Stanley Morehouse, member A.S.M.E., gave a brief talk on the advantages of being a student member of the A.S.M.E. Mr. Herbert Bansbach gave an interesting lecture on "Marine Boilers."

Unique Smoker at Virginia

On September 6 the VIRGINIA POLYTECHNIC BRANCH held a smoker. An interesting program was presented under the direction of a program committee consisting of H. W. Fleming, H. G. Powers, and T. E. Hall. A large number of pictures of people, places, ships, and airplanes in the news, as well as pictures of various machines and things of technical interest, were displayed on boards to be identified by those present. Cigarettes were given as prizes for the two persons identifying the greatest number the quickest. This program was immensely enjoyed.

WEST VIRGINIA BRANCH of the A.S.M.E. held four meetings during the month of August. At these meetings good talks were given by P. Muffly, "Launching a Ship;" F. Pritchard, "Nonsegregating Coal Chute;" J. Kennedy, "Oil From Canadian Sands;" C. Lewis, "Engineer at War;" R. Jenkins, "Subzero Temperature for Shrink Fits;" J. Murray, "Shaver Gears for Aircraft Engines;" B. Judy, "Micro-Hardness Tests;" F. Mumma, "High-Frequency Induction Hardening;" W. McCoy, "Plywood by Multidirectional Pressure;" T. Olsen, "Salvage of the *Normandie;*" F. Pritchard, "Bombproofing Utilities;" J. Rowe, "How to Be a Good Foreman;" and J. Wargacki, "Producer Gas."

Membership Drive Planned at Worcester

On August 11 the WORCESTER POLYTECHNIC BRANCH met and elected a new president as the former president was called to service. Fred Moulton was elected president for the remainder of the present senior term. A membership campaign was planned for the coming year. Mr. John Hitchcock, member A.S.M.E., engineer at the Morgan Construction Company, then spoke on "Principles of a Rolling Mill and Its Design." This branch met again on September 15 and it was reported that this year's membership drive had netted 64 members. The Riley Stoker Company sent 3 representatives, Messrs. Hawley, Smith, and Krieger, to give a picture of a modern steam-generating plant.

W.M.C. Issues Apprentice Training Pamphlets

TWO small pamphlets relating to the training of apprentices have been recently issued by the War Manpower Commission and are available at the offices of the Commission in Washington or at any of its regional offices.

"Training Apprentices for War and Postwar Work" is the second edition of this pamphlet, originally published as an article in *Factory Management and Maintenance*, to which a section, "Adapting Apprenticeship to War Conditions," has been added. The pamphlet states that "we consider it of paramount importance to give returning soldiers, who wish to learn a trade, the opportunity to do so."

"St. Louis, Missouri, and Vicinity Machinist Apprenticeship Standards," is the second pamphlet. These standards of apprenticeship were jointly developed by employers and employees. Their purpose is "to develop apprentices in all the practical and theoretical aspects of the trade throughout this area; to preserve and perpetuate the skills essential to true craftmanship, and to build up and maintain the ranks of all-round skilled machinists."

The standards include an apprenticeship agreement, an application form, an apprentice's master record card form, and an apprentice's monthly-work-record form.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
8 West 40th St.	4 Park St.	211 West Wacker Drive	100 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

GRADUATE MECHANICAL ENGINEER, 38, chief engineer in charge of design and estimating of process equipment for chemical and petroleum industries. Desires position as executive engineer in industry offering postwar opportunities. Me-816.

MAINTENANCE ENGINEER, 53, with long varied experience in plant maintenance, engineering, and construction. Ability in the handling of men and organizing for efficiency. Past fifteen years in the chemical industry. Now employed in South. Me-817.

POSITIONS AVAILABLE

ASSISTANT STANDARD ENGINEER with a technical education and a good knowledge of drafting on electrical and mechanical parts. Should also have some knowledge of sources of supply. About $65 per week for a 48-hour week. New York metropolitan area. W-2766.

CHIEF ENGINEER. Must be able to direct machine shop operations, be able to tool up projects, and make estimate of operations costs. Salary open. Permanent. New York metropolitan area. W-2772.

MECHANICAL ENGINEERS familiar with designing and detailing of material handling and hoisting machinery. Some experience with structural frames would be helpful, not essential. Salary open, dependent upon qualifications. Apply by letter stating salary desired. Northern New Jersey. W-2778.

ASSISTANT EXECUTIVE ENGINEER, 35–45, with background of industrial experience in manufacturing plants. General business and financial experience essential. Latin American experience desirable. $5600–$8000 year. Washington, D. C. W-2779.

DEVELOPMENT PROCESS ENGINEERS to take various mechanical processes and make specific improvements. Company in textile field. $3500–$4000 a year plus bonus. Permanent. New England. W-2780B.

PRODUCTION MANAGER thoroughly experienced in production of veneered furniture. Plant employs about 100 men and women. The materials going into the product manufactured consist of veneers and glue and process is largely veneer and finishing. About $6000 year plus bonus. Location, Massachusetts. W-2783.

DESIGN AND DEVELOPMENT ENGINEER to design and develop all types of automatic valves, pump regulators, liquid level indicators, recording, pressure, temperature, flow, etc., instruments. Salary open. Permanent. Pennsylvania. W-2785-B314.

DEVELOPMENT ENGINEER, 35–45, to head up a research and development division. Should have engineering training and be experienced in production and development work. Will discover and investigate new developments, evaluate desirability of company entering new or related fields, and make sound recommendations and substantiate them with facts. Permanent. Location, upper New York State. W-2789.

ASSEMBLING ENGINEER, experienced in and capable of laying out and setting up final assembly department from scratch, co-ordinating and directing various incoming subassemblies and parts to final assembly line on war work similar to heavy trucks, light tanks, and products of that nature. Write giving complete information. Salary substantial. For the duration, possibly permanent. W-2790-D.

MECHANICAL DEVELOPMENT ENGINEER with at least 10 years' experience on the design and development of mechanical devices. Experience on airplane starters or propellers would be desirable. Permanent. $8500 a year. Michigan. W-2829-CD.

PERSONNEL DIRECTOR who has had experience in machine shop, foundry, forge, pattern shop. Duties will be selection, training, evaluation, grievances, Manning tables, separations, War Labor and union negotiations. $4800–$6000 a year. Location, Pennsylvania. W-2839.

MANAGEMENT ENGINEERS, 38–50. Must have capabilities to take over the complete management of textile knitting mill. Should have had complete training in time study, methods, and incentives. Must have poise and a quality to supervise subordinates. Permanent. Salary open. New England area. W-2850.

GRADUATE MECHANICAL ENGINEER who is fully experienced in machine-screw operations, tapping, swedging, etc. Will be responsible for production of equipment in subcontractors plant and also assembly work. Should be man who has had practical experience and capable of estimating costs, and planning work through the plant. Salary about $8000. Northern New Jersey. W-2858.

DESIGNING ENGINEER, mechanical, with some experience in design of material-handling equipment. Prefer man with some structural. along with equipment, design. Salary open, Permanent. Northern New York State. W-2859.

MECHANICAL ENGINEER, preferably older man with background of machine-shop production methods and design. Should have good knowledge of dies. Work will involve general all-around engineering and management of small progressive plant. Salary about $5000. New York metropolitan area. W-2863.

INDUSTRIAL ENGINEERS. Should be capable in direction of industrial-engineering program. Must have good background in plant layout, time study, processing, estimating, and methods. Company interested in men with some experience in one or all of these classifications. Salary is open. Location, Maryland. W-2877.

DESIGNER for new product design. Must have had considerable experience, preferably in varied phases of mechanical design, also knowledge of materials and machining. Salary, about $4200. Permanent. New York, N.Y. W-2879.

ASSISTANT SUPERINTENDENT, about 35, of power, graduate, for modern high-pressure industrial power plant and process steam-distribution system in well-established basic industry. Experience in feedwater treatment and personnel handling desirable. Northeastern Ohio. W-2880D.

WORKS MANAGER, under 45, for electrical company. Electrical engineer preferred but will consider mechanical. Must have good, all-over production experience. $15,000–$16,000 a year. Middle West. W-2881.

PLANT SUPERINTENDENT with experience with type of heavy equipment used in quarries, clay operations, lime plants, mines, or heavy construction. Cement manufacturing experience desirable but not necessary. Apply by letter stating experience, draft status, reason for leaving previous employer, and previous salaries received. Michigan. W-2884-D.

[1] All men listed hold some form of A.S.M.E. membership.

Hoover Medal Board Passes Resolutions on Death of Conrad N. Lauer

THE following resolutions on the death of Conrad N. Lauer, past-president, A.S.M.E. and founder of the Hoover Medal, have been transmitted to his family and have been incorporated in the official records of the Hoover Medal Board of Award.

WHEREAS the Hoover Gold Medal, awarded to commemorate the civic and humanitarian

(*A.S.M.E.News continued on page 840*)

achievements of engineers, was instituted in 1929 through the generosity and public spirit of Conrad N. Lauer, and

WHEREAS Mr. Lauer had devoted his thoughts and energies to raising the status of the engineering profession and had exemplified the qualities he hoped to encourage in others in services to his community and the engineering profession,

Be it resolved that the members of the Hoover Medal Board of Award hereby record in the Minutes their sorrow in the loss of one whose life was distinguished and filled with good works.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after November 26, 1943, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

AFRICANO, ALFRED, Indian Head, Md.
AUSTIN, HENRY WARNER, Washington 19, D. C. (Rt)
BALDWIN, HOWARD D., Wilkes-Barre, Pa.
BARTLETT, LUIS H., Austin 12, Texas
BLACKMORE, WILLIAM, Cleveland, Ohio
BLAIR, J. S., Leicestershire, England
BOND, W. ROGER, Mansfield, Mass.
BRUMMERSTEDT, EGON F., New York, N. Y.
BURK, EDWIN H., Overbrook, Pa.
BUTLER, L., Greenwich, Conn.
CARLISS, OSWALD S., Fairfield, Conn.
CHAPMAN, PAUL A., Elizabethton, Tenn.
CICHELLI, ANDREW E., Baltimore, Md.
CLARK, THOMAS C., JR., Clayton, Mo.
CONSLEY, J. M., JR., Seattle 4, Wash. (Rt & T)
DAWSON, E. F., Norman, Okla. (Rt)
DERROM, D. L., New York, N. Y. (Rt)
DI PRIMA, ANTHONY, Brooklyn, N. Y.
ENTWISTLE, A. L., Louisville 1, Ky.
FANKHAUSER, ARNOLD F. E., Fort Wayne, Ind.
FARNSWORTH, AUGUSTUS P., Darien, Conn.
FITZGERALD, GILBERT, Baltimore 20, Md.
FLEMING, ROBT. M., Painesville, Ohio
FOSTER, E. W., Mimico, Ont., Can.
FROEHLICH, KURT, Milwaukee 7, Wis.
GAZIN, W. R., Lombard, Ill.
GODLEY, E. B., Huntington, W. Va.
GRAVES, FREDERICK E., Columbus, Ohio
GRAY, CECIL, Richmond, Va.
GREEN, ALLEN P., Mexico, Miss.
HAAKONSEN, OLE, Brooklyn, N. Y.
HARVEY, JAS. E., Rochester, N. Y.
HILLMAN, FRED W., Ontario, Calif.
HORNBERGER, WILLIAM, Oakland, Calif.
HUNTER, JOHN A., Worcester 3, Mass.
KEARNEY, JOHN GORDON, New York, N. Y.
KETCHAM, C. B., Cincinnati 11, Ohio
KIMMELL, PHILLIP M., Rochester, N. Y.
KINCAID, LEROY M., Albemarle, N. C.
KLAUBERG, WALTER E., Houston, Texas
LEHMAN, ARTHUR W., Doylestown, Pa.
LEWIS, O. K., JR., Oak Ridge, Tenn. (Re)
LEWIS, PHILIP, Bronx, N. Y.
LILLYBLAD, R. H., Grand Haven, Mich.
LINCOLN, J. D., Marion, Virginia
LINDERMAN, HAROLD C., Pittsburgh 30, Pa.
LININGER, BYRON W., Wilmington, Del.
MACARTHUR, S. H., Scarsdale, N. Y.
MACMASTER, RONALD K., Elizabeth 3, N. J. (Rt)
MAIRNE, CLAYTON L., New Orleans 9, La.
MARSHALL, HARRY D., JR., Grand Rapids, Mich.
MCKEE, W. R., Wellsville, N. Y.
MILLER, C. B., Youngstown, Ohio
MILLER, W. J. H., Bridgeport, Conn.
MOERK, J. CARROLL, Philadelphia, Pa.
MOLINARI, WILFRED H., Penns Grove, N. J.
MUSCHAMP, GEORGE M., Philadelphia 44, Pa.
PEIRCE, THOMAS H., Detroit, Mich.
PENDLETON, PYAM L., Edgewood 5, R. I.
PETERSON, N. TRUMOND, Los Angeles, Calif.
RABINOW, DAVID, Elizabeth, N. J.
RIDER, HARRY N., Youngstown, Ohio (Rt)
ROSENTHAL, PAUL, Chicago 13, Ill.
SCHENKE, KURTISS P., New York 17, N. Y.
SHARPE, H. W., North Bay, Ontario, Canada
SHENK, DONALD H., Tuscaloosa, Ala. (Rt)
SIEFERT, CHAS. G., Cleveland Heights, Ohio
SIMPSON, W. H., New York, N. Y.
SKROTZKI, BERNHARDT G. A., Lynbrook, N. Y. (Rt & T)
SMART, FRANK, Bronxville, N. Y.
SMITH, S. V., Indianapolis, Ind.
SOMERVELL, S. BRUCE, New York, N. Y.
SPURLOCK, BENJAMIN H., JR., Boulder, Colo.
SYGALL, O. T., New York 24, N. Y.
TASKIN, H., Milwaukee, Wis.
THOMPSON, HENRY H., Washington, D. C.
TOLE, J. H., Memphis, Tenn.
TOOMEY, THOMAS C., West Brighton, N. Y. (Rt)
VAN DERVEER, WM. W., Jackson Heights, N. Y.
WARD, WALLACE W., Bloomfield, N. J.
WILKINS, W. BURDETTE, Danvers, Mass.
WILLIAMS, R. E., JR., Birmingham, Ala.
WOLF, C. E., New Martinsville, W. Va. (Rt)
ZIMMERMAN, LAWRENCE E., Chicago, Ill.

CHANGE OF GRADING

Transfers to Fellow

HIGLEY, FRANK R., Cleveland Heights, Ohio
WHITAKER, H. E., New York, N. Y.
WITT, J. C., Chicago, Ill.

Transfers from Junior

BELTRAN, EDWARD V., Brooklyn, N. Y.
CARSPECKEN, HENRY L., JR., S. Charleston, W. Va.
HENDERSON, JOHN R., Swampscott, Mass.
JEWETT, GEORGE L., Hingham, Mass.

(*Continued in next column*)

KNIFFEN, ALLEN T., New York, N. Y.
LANE, DONALD F., Sparrows Point, Md.
LLOYD, JOHN A., Wilkes-Barre, Pa.
MANSFIELD, ERNEST B., Akron, Ohio
UNGER, LOUIS F. (CAPT.), Philadelphia, Pa.
WEBER, WILLIAM R. (LIEUT. COL.), Winston Salem, N. C.
WINTZER, HERMAN C., Hopewell, Va.

Necrology

THE deaths of the following members have recently been reported to headquarters:

ABBOTT, CHARLES C., April 26, 1943
ALLSTRAND, HARRY P., September 6, 1943
BLAKELEY, GEORGE H., December 25, 1942
DAVISON, CHARLES R., September 20, 1943
DUVILLARD, HENRY A., July 31, 1943
FINK, E. C., January 1, 1943
FLETCHER, F. RICHMOND, January 24, 1943
FREEMAN, FREDERICK S., July 17, 1943
GRESSLY, OSCAR E., April 17, 1943
HOFFMAN, PAUL, September 11, 1943
KOCH, ALVIN FRED, March 23, 1943*
MATSCHOSS, CONRAD, March 21, 1942
MONTAGUE, CHARLES E., May 22, 1943
PIERNAK, JOHN, September 3, 1943
STADTFELD, SANFORD, November 30, 1942*
WELCH, HALBERT A., July 24, 1943

*Died in line of duty.

A.S.M.E. Transactions for October, 1943

THE October, 1943, issue of the Transactions of the A.S.M.E. contains:

Removal of Water-Insoluble Turbine Deposits by Caustic Washing, by W. L. Webb and R. G. Call

Chemical Removal of Scale From Heat-Exchange Equipment, by F. N. Alquist, C. H. Groom, and G. F. Williams

Delamination Tests of Plywood and a Proposed Specification, by C. W. Muhlenbruch

Some Observations on Density and Shrinkage of Ponderosa Pine Wood, by R. A. Cockrell

Overfire Air Jets, by R. B. Engdahl and W. C. Holton

Heat Transfer and Pressure Drop in Annuli, by Elmer S. Davis

Creep of Metals at Elevated Temperatures—the Hyperbolic-Sine Relation Between Stress and Creep Rate, by P. G. McVetty

Rate of Ice Formation, by A. L. London and R. A. Seban

Performance and Selection of Mechanical-Draft Cooling Towers, by Joseph Lichtenstein

Heat Transfer to a Fluid Flowing Periodically at Low Frequencies in a Vertical Tube, by R. C. Martinelli, L. M. K. Boelter, E. B. Weinberg, and S. Yakahi

Theoretical and Experimental Investigations of Thin-Webbed Plate-Girder Beams, by H. L. Langhaar

Application of Turbine-Supervisory Instruments to Power-Generating Equipment, by J. L. Roberts and H. M. Dimond

Largest A.S.M.E. Annual Meeting Ever Held to Take Place in New York, at Hotel Pennsylvania, Nov. 29-Dec. 3

Tentative Technical Program Announced by Meetings and Program Committee

JUSTIFICATION for planning in wartime the largest Annual Meeting of The American Society of Mechanical Engineers ever held with an attendance expected to overshadow any ever recorded in the past can only be found in the fact that free and immediate exchange of technical information is essential to the winning of a war whose successful conclusion depends to a considerable extent on the development of new ideas, devices, and equipment and on the increasing efficiency of production.

Importance to War Effort

Mechanical engineers can never be too busy with the routine of their jobs, no matter how important those jobs may be, to pass up the opportunity of learning how to perform those jobs better and more quickly. Recent reports from the battle fronts show that the enemy is exerting every talent and developing every resource at his command in efforts to increase his production and to meet the menace of invasion and attack with new weapons and improved defensive techniques.

These attempts on the part of the enemy to regain a lost superiority cannot be successful if the engineers of this and other allied nations continue to be on the alert in whatever branches of the war effort they are directly or indirectly concerned.

It was considerations such as the foregoing that prompted the Council of The American Society of Mechanical Engineers to authorize the divisions and committees of the Society to plan the 1943 Annual Meeting with its crowded and diversified program.

Dates—Nov. 29–Dec. 3

The 1943 A.S.M.E. Annual Meeting will be held during the week beginning Sunday, November 28, and will continue through Saturday, December 4, with scheduled events for every hour of these crowded days.

Headquarters—Pennsylvania Hotel

Having outgrown, because of size and diversification, the facilities of the Engineering Societies Building, built 35 years ago as a home and meeting place for the nation's engineers, the A.S.M.E. Annual Meeting has, for several years, been forced to utilize the larger and more elastic facilities of metropolitan hotels. Headquarters for the 1943 meeting are to be in the Hotel Pennsylvania, Seventh Avenue at Thirty-Third Street, New York City, directly opposite the Pennsylvania Railroad Station and conveniently located (by underground passages), with all of New York's important subways. The arrangement of the hotel is such that the convention is held in the eastern portion of the building which is sufficiently separated from the main lobby and other public rooms of the hotel to insure adequate space with reasonable privacy. The Committee on Meetings and Program, which chose the Hotel Pennsylvania as headquarters, is convinced that members of the Society will approve the choice.

Official Notice

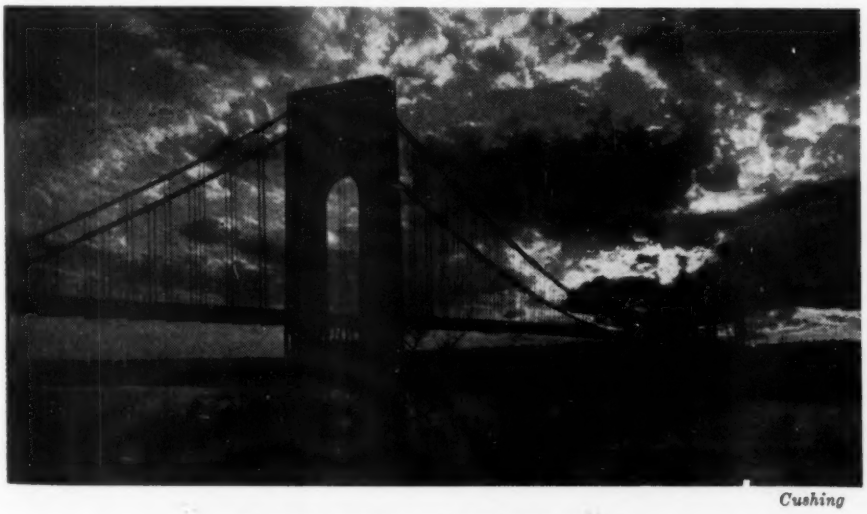
A.S.M.E. Business Meetng

THE Annual Business Meeting of the members of The American Society of Mechanical Engineers will be held on Monday afternoon, November 29, 1943, at 4:00 p.m. at the Pennsylvania Hotel, New York, N. Y., as a part of the Annual Meeting of the Society.

Early Reservations Necessary

It must not be forgotten, however, that New York is crowded at all times, that reservations for train travel are hard to get at the last moment, and that luncheons and dinners at A.S.M.E. Meetings have been sold out early every year for some time. Reservations for hotel rooms and tickets for luncheons and the Annual Dinner have been pouring in to A.S.M.E. headquarters ever since the preliminary announcement of the meeting made in last month's issue urged instant action. Let us repeat the warning once more.

This is going to be the largest A.S.M.E. meeting on record. It is going to provide the largest, most varied, and most important program of papers and discussions ever presented. It is being held under conditions that demand early registration and reservation for hotel rooms and tickets for luncheons and dinners. Even if you may be forced to cancel reservations later, make them at once



Cushing

GEORGE WASHINGTON MEMORIAL BRIDGE

and thus avoid both disappointment and inconvenience.

Usual A.S.M.E. Pattern to Be Followed

Every A.S.M.E. Annual Meeting follows a well known pattern. Except for size and variety, this year's pattern will be familiar to all members. There will be the usual Society committee meetings which are important to those who serve on these committees. The Council will meet. The Annual Business Meeting of A.S.M.E. Members will be held as usual. The Conference of Local Section Group Delegates will begin its session early (on Sunday) and will continue until its work is completed. Dozens of committees, some of which meet frequently and others of which come together only annually, will get together.

Get a General Picture

The technical program will commence on Monday noon, with a luncheon, and continue through Friday every morning afternoon and evening except Wednesday evening, which, as usual, is reserved for the Annual Banquet. Public and private luncheons and dinners will fill in the few hours that separate the groups of simultaneous sessions, of which there will be from five to seven scheduled for each block of technical-program time. No man can take it all in without being quintuplets and without mental indigestion. But every man can study the program, printed in tentative form in the following pages, and make up his own personal schedule of sessions and events that lie closest to his interests and needs. Study that program now. Get a general picture of what is most important to you, check it with the final program you will receive on registering, and then make the most of the greatest opportunity for concentrated absorption of information, impressions, and contacts that has ever come your way.

Improved Headquarters Facilities

One of the improved features of the Pennsylvania Hotel headquarters will be the more enjoyable facilities for those contacts and renewed acquaintanceships which, to many members, are the best part of an A.S.M.E. Meeting. In so far as such a thing is possible, the convention will be closely concentrated in an area designed for the holding of conventions. There will be ample space to sit around and chat for those who are not compelled to be in technical sessions and committee meetings. It is a mere hop, skip, and a jump to any meeting room, luncheon, or other event. The registration headquarters, as was the case in former years when meetings were held in the Engineering Societies Building, will also be the social headquarters of this meeting. Most of the old-time atmosphere will be recaptured on a grand scale.

Technical Program Full and Varied

It would be tiresome and useless to detail the technical program in a description of its varied features. Reference to the tentative program printed in the following pages will be sufficient to convince every member of the magnitude, variety, and importance to the war effort of the papers that have been prepared. Here the names of the authors and the subjects they will discuss will be found. Practically every professional division and many technical committees, which are the program-making agencies of the Society, are represented on this program. The old timer will need no assistance in picking out what interests him most. New divisions and new committees are represented and careful scrutiny is needed to guard against passing up something that is new or extraordinary.

Luncheons and Dinners

The luncheons sponsored by the Committee on Education and Training for the Industries, opener of recent meeting programs, of the Management, Aviation, Railroad, and Textile Divisions will be found as usual. The Applied Mechanics Division Annual Dinner, held jointly this year with the Society for Experimental Stress Analysis which is cooperating in the technical sessions of the Division, will be found scheduled for Friday evening. An unusual feature, a Saturday morning session, will be held jointly by the Applied Mechanics Division and the S.E.S.A., a welcome newcomer in the technical society field.

Damon to Be Dinner Speaker

At the 1943 Annual Dinner, which will be held in the ballroom of the Hotel Pennsylvania on Wednesday evening, December 1, Ralph S. Damon, vice-president and general manager, American Air Lines, Laguardia Field, New York, N. Y., will deliver the principal address. Mr. Damon's subject will be "Aviation During and After the War."

In accordance with a custom of several years' standing, the honors and awards for 1943 will be presented at the dinner, and a number of distinguished engineers will receive certificates of honorary membership. The list of this years' awards and honorary memberships will be found on page 848 of this issue.

In addition to the Society's own awards, three important engineering honors will be conferred at the dinner: the John Fitz Medal, the Henry L. Gantt Medal, the Hoover Medal, and the Nobel Prize.

Biomechanics Session

Special mention may be made of the session on Thursday evening sponsored by one of the Societies newest committees on the subject of biomechanics. This committee of the Aviation Division has an ambitious program ahead of it and this year's Annual Meeting affords the Committee an opportunity for its first public session. Anyone interested in safety in flying and in saving the lives of airplane pilots will find this session worth while. Although biomechanics has applications in many and varied fields, the committee's immediate task lies in aviation. Co-operation of the medical profession has been secured and the blessing of governmental agencies in this and other countries has been given informally to the program.

A.P.C. Patent Exhibit

A feature of the 1943 Annual Meeting will be the display of some 40,000 patents taken over by the Office of Alien Property Custodian and offered for license by any one interested in developing one or more of them in this country. Opportunity will be afforded members and guests to acquaint themselves with opportunities for securing licenses under the procedure of the Office of Alien Property Custodian.

For those unable to attend the meeting copies of a leaflet "Index of Patents Vested in the Alien Property Custodian," may be secured by writing to the Alien Property Custodian, Division of Patent Administration, Field Building, Chicago 3, Ill. An instruction sheet giving necessary information on how to proceed is also available. A $15 fee is charged for each patent licensed.

There are patents in practically every field of the mechanical, electrical, and chemical arts, and manufacturers searching for new products should examine these patents and applications.

Registration Fee for Non-Members at the 1943 Annual Meeting

There will be a registration fee of $2 for nonmembers attending the 1943 Annual Meeting. For nonmembers wishing to attend just one session (except evening sessions or meal meetings) the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests (male) may avoid this fee by writing to the Secretary of the Society before November 22 asking for a guest-attendance card for the Annual Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member*.

Program of A.S.M.E. Sixty-Fourth Annual Meeting

New York, N. Y., Nov. 29–Dec. 3, 1943

Headquarters Hotel Pennsylvania

SUNDAY, NOVEMBER 28

9:30 a.m.

Meeting Executive Committee of Council
Conference Local Sections Delegates

12:30 p.m.

Luncheon Council and Local Sections Delegates

2:30 p.m.

Meeting of Council
Meeting Local Sections Delegates

7:00 p.m.

Meeting of Council with Professional Divisions, Section Delegates, and Committee Representatives

MONDAY, NOVEMBER 29

9:30 a.m.

Meeting of Council
Conference of Local Sections Delegates

12:30 p.m.

Luncheon, Committee on Education and Training

Speaker: Charles F. Kettering

2:00 p.m.

Education and Training (I)

4:00 p.m.

Business meeting

8:00 p.m.

The Relation of Foremen to Management and to Organized Labor

The Foreman—His Past and Present, by J. E. Walters, vice-president, Personnel and Labor Relations, Revere Copper and Brass, Inc.

Union Membership and Collective Bargaining by Foremen, by Robert H. Keys, president, Foremen's Association of America

The Foreman as a Member of Management, by Harry B. Coen, assistant to vice-president in charge of Personnel Relations, General Motors Corporation.

Furnace Performance Factors (I)—Power

2500-Psi Twin Branch Plant Experiments

Operating History of the 2500-Psi Twin Branch Plant,* by Philip Sporn, vice-president, American Gas & Electric Corporation New York, N. Y., and E. G. Bailey, vice-president, The Babcock & Wilcox Co., New York, N. Y.

* To be preprinted for 1943 Annual Meeting.

MONDAY (*continued*)

Natural Circulation Test Results in the 2500-Psi Twin Branch Boiler,* by W. H. Rowand, The Babcock & Wilcox Co., and T. B. Allardice, American Gas & Electric Corporation, New York, N. Y.

Distribution of Heat Absorption and Factors Affecting the Performance of the Twin Branch 2500-Psi, 940 F Boiler With Reheat to 900 F,* by E. G. Ely, The Babcock & Wilcox Co., and L. B. Schueler, American Gas & Electric Corporation, New York, N. Y.

Ingenuity

The Psychological Setting for Inventiveness, by Elliott Dunlap Smith, professor of Economics, Yale University, New Haven, Conn.

What Our Educational Institutions Can Do for the Genius, by Henry T. Heald, president, Illinois Institute of Technology, Chicago, Ill.

Yankee Ingenuity in Engineering, by W. L. Merrill, engineer of works laboratory, General Electric Co., Schenectady, N. Y.

Fuels (I)

Combustion of Barley Anthracite, by Allen J. Johnson, mechanical engineer, Anthracite Industries, Inc., Philadelphia, Pa.

New Combustion Methods for All Standard Fuels, by Robert Reed, engineer, John Zink Burner Co., Tulsa, Okla.

Production Engineering (I)

Symposium on High-Speed Milling

TUESDAY, NOVEMBER 30

9:30 a.m.

Quality Control

Quality Control in the Manufacture of Small Arms Ammunitions, by Hugh M. Smallwood, U. S. Rubber Co., Eauclaire, Mich.

Quality Control for Thermosetting Plastic Materials and Products, by J. J. Pyle and H. M. Richardson, General Electric Co., Pittsfield, Mass.

The Inspection Control System of the Signal Corps, by Lieut. Col. G. L. Schnable, Signal Corps Inspection Agency, War Department, Dayton, Ohio

Metal Cutting Research (I)

Elements to Be Considered in Milling Steel With Cemented Carbide Tipped

TUESDAY (*continued*)

Milling Cutters, by Fred W. Lucht, development engineer, The Carboloy Co., Inc., Detroit, Mich.

Standardization of Tool Life Tests for Evaluating the Machinability of Single Point Tools, Cutting Fluids, or Materials Cut,* by O. W. Boston, University of Michigan, Ann Arbor, Mich.

Thermodynamics—Fluid Mechanics

Nozzles for Supersonic Flow Without Shock Fronts,* by A. H. Shapiro, Massachusetts Institute of Technology, Cambridge, Mass.

Oscillations in Closed Surge Tanks,* by A. M. Binnie, Oxford University, (to be presented by H. W. Emmons, Harvard University)

The Second Law of Thermodynamics for Changes of State and Quantity of the Working Substance, With Particular Reference to Steam Engines,* by the late G. Zerkowitz, Illinois Institute of Technology, Chicago, Ill. (to be presented by J. H. Keenan, Massachusetts Institute of Technology)

Heat Effects in Lubricating Films, by A. C. Hagg, Westinghouse Electric & Manufacturing Co. East Pittsburgh, Pa.

High-Temperature-Steam Corrosion

High-Temperature-Steam Corrosion Studies in Detroit,* by I. A. Rohrig, R. M. Van Duzer, Jr., and C. H. Fellows, The Detroit Edison Co., Detroit, Mich.

The Corrosion of Alloy Steels by High-Temperature Steam,* by G. A. Hawkins, J. T. Agnew, and H. L. Solberg, Purdue University, Lafayette, Ind.

Education and Training (II)

Technical Training of Women for the Aircraft Industry, by C. Wilson Cole, head, training division, Wright Aeronautical Corporation, Paterson, N. J.

Technical Training of Women for the Radio Industry, by Forest H. Kirkpatrick and Frances M. Tallmadge, personnel planning and research department, RCA Victor Division, Radio Corporation of America, Camden, N. J.

E.S.M.W.T. for Women, by J. I. Yellott and Cornelia Howe, War Training Division, Illinois Institute of Technology, Chicago, Ill.

Aviation—Production Engineering

High-Speed Spar Milling, by Paul Dubo-

(*Program continued on page 844*)

TUESDAY (*continued*)

sclard, president, Farnham Manufacturing Co., Buffalo, N. Y.

Analysis of Stretch-Forming Double-Curved Sheet-Metal Parts,* by R. B. Glassco, Stress Analyst, Lockheed Aircraft Corporation, Burbank, and N. O. Myklestad, research associate in aeronautics, Guggenheim Aeronautics Laboratory, California Institute of Technology, Pasadena, Calif.

12:30 p.m.

Management Luncheon

The Job Ahead for Management: Two-minute talks by twelve prominent engineers

2:00 p.m.

Boiler Feedwater Studies

A New Approach to the Problem of Conditioning Water for Steam Generation, by R. E. Hall, director, Hall Laboratories, Inc., Pittsburgh, Pa.

Chip Control

Symposium:

Increasing Tool Life by Better Tool Finishing,* by V. H. Ericson, The Norton Co., Worcester, Mass.

Chip Control With Sintered Carbide Tools, by M. F. Judkins, Firthite Division, Firth-Sterling Steel Co., McKeesport, Pa.

Standardization of Chip-Breaker Type of Fine-Finished Single-Point Cutting Tools,* by Carl J. Wiberg, production engineering department, Wright Aeronautical Corporation, Paterson, N. J.

The Practical Aspects of Chip Control, by Frank J. Oliver, *The Iron Age*, New York, N. Y.

New Principles in the Design, Generation, and Maintenance of Cutting Tools, with a demonstration of the Bura-way grinder for grinding single-point tools, by Walter M. Bura, The James Donaldson Co., Inc., New York, N. Y.

Aviation—Instruments and Regulators

Radiation Pyrometry in Supercharger Testing, by V. P. Head, supercharger engineering division, General Electric Co., W. Lynn, Mass., and R. H. Norris, general engineering laboratories, General Electric Co., Schenectady, N. Y.

High-Speed Multiple-Point Potentiometer Recorder Measurement of Thermocouple Temperatures During Flight Tests of Planes, by I. M. Stein, A J. Williams, Jr., and W. R. Clark, Leeds & Northrup Co., Philadelphia, Pa.

Progress Report of Committee on Terminology, by H. F. Moore, chairman

Postwar Planning

The Critical Period of Transition After V-Day, by John F. Fennelly, executive director, Committee for Economic Development

Production—The Key to the Maintenance of Freedom, by Paul G. Hoffman, chairman, Committee for Economic Development and president, The Studebaker Corporation

Aviation—Applied Mechanics

Landing Shock Effects on an Airplane Considered as an Elastic Body, by E. G. Keller, consulting engineer, Lockheed Aircraft Corporation, Burbank, Calif.

The Stresses in Cemented Joints, by M. E. Reissner, Massachusetts Institute of Technology, Cambridge, Mass., and M. Goland, research laboratory, Curtiss-Wright Corporation, Buffalo, N.Y.

The Effects of Web Deformation on the Torsion of I-Beams, by J. N. Goodier, Cornell University, Ithaca, N. Y., and M. V. Barton, University of Texas, Austin, Texas

Fuels (II)

Combustion in High-Pressure Chambers, by Eric G. Peterson, manager, air-heater department, Peabody Engineering Co., New York, N. Y.

An Evaluation of the Importance of Physical and Chemical Properties of Fly Ash in Creating Commercial Outlets for the Material, by C. M. Weinheimer, in charge mechanical division, research department, The Detroit Edison Co., Detroit Mich.

Fuel and Its Research in England During the War, by W. C. Schroeder, assistant chief, Fuels and Explosives Service, Bureau of Mines, Washington, D. C.

8:00 p.m.

Instruments and Regulators

Symposium on Wartime Problems of Industrial-Instrument Department

Minimizing Instrument Maintenance in Designing Aviation Gasoline Plants, by D. J. Bergman and G. G. Gallagher, Universal Oil Products Co., Chicago, Ill.

Problems in Obtaining Personnel in the Wartime Operation of an Instrument Department, by G. P. Bosomworth, Firestone Tire and Rubber Co., Akron, Ohio

Training Men for the Government Magnesium and Styrene Plants, by R. W. Cermak, Dow Chemical Co., Midland, Mich.

The Influence of Wartime Materials Economy Upon Instrument and Mechanism Engineering, by T. A. Cohen, Wheelco Instrument Co., Chicago, Ill.

Interesting Experiences in Starting Up Recent Process Units, by H. F. Moore and W. C. Ludi, Standard Oil Development Co., Elizabeth, N. J.

Instruments Piping, Tubing, and Fittings During Wartime, R. D. Webb, Carbide & Carbon Chemical Corporation, So. Charleston, West Va.

Metal Cutting Research (II)

Practical Cutting-Fluid Recommendations for Use With High-Speed-Steel Tools,* by O. W. Boston, University of Michigan, Ann Arbor, Mich, H. L. Moir, Pure Oil Co., Chicago, Ill., E. M. Slaughter, Republic Steel Co., Detroit, Mich., and W. H. Oldacre, D. A. Stuart & Co., Chicago, Ill.

Metal-Cutting Nomograph for Cutting Steel With Single-Point Tools,* by W. W. Gilbert and W. C. Truckenmiller, University of Michigan, Ann Arbor, Mich.

Production Research Panel

What Most Needs to Be Done in the Way of Production Research at This Time?

Accelerating Scientific Management in the Federal Government

Panel Discussion

Arthur S. Flemming, Commissioner, U. S. Civil Service Commission; W. A. Jump, director of finance, U. S. Department of Agriculture; J. M. Juran, administrator, Office of Lend-Lease Administration; L. A. Appley, deputy chairman and executive director, War Manpower Commission, Washington, D. C.

Aviation (I)

Principles of Air Cargo Design, by A. Klemin, New York University, New York, N. Y.

High-Altitude Hot-Gas Standards for Testing Turbosuperchargers and Engines, by E. E. Stoeckly, General Electric Co., West Lynn, Mass.

Symposium—Boiler Fan Selection and Use

Participants: W. S. Patterson, Combustion Engineering Co., New York, N. Y., M. S. Kice, American Blower Co., Dearborn, Mich.; H. F. Hagen, B. F. Sturtevant Co., Boston, Mass.; P. S. Dickey, Bailey Meter Co., Cleveland, Ohio; J. J. Grob, Consolidated Edison Co., New York, N. Y.

WEDNESDAY, DECEMBER 1

9:30 a.m.

Aviation (II)

Gas Turbines and Turbosuperchargers,* by Sanford A. Moss, consulting engineer, General Electric Co., W. Lynn, Mass.

Airplane Cabin Pressurization, by Charles W. Norris, project engineer, Airsearch Manufacturing Co., Los Angeles, Calif.

Cabin Supercharger Test Chamber of General Electric Co., by J. H. Bright-

(*Program continued on page 845*)

WEDNESDAY (*continued*)

man, refrigeration engineering department, General Electric Co., Schenectady, N. Y.

Vibration

Forced and Free Motion of a Mass on an Air Spring,* by B. Sussholz, David Taylor Model Basin, Navy Department, Washington, D. C.

Pi-Tee Transformations in the Analysis of Mechanical Transmission Lines, by G. Horvay and S. Pines, David W. Taylor Model Basin, Navy Department, Washington, D. C.

Measurement of the Damping of Engineering Materials During Flexural Vibration at Elevated Temperatures,* by C. Schabtach and R. O. Fehr, General Electric Co., Schenectady, N. Y.

Furnace Performance Factors (II)

Papers on furnace geometry of large furnaces

Incentives

Survey of Incentives Under Wartime Conditions

Papers by James F. Lincoln, president, Lincoln Electric Company, Cleveland, Ohio; John F. Campbell, plant manager, International Projector Corporation, New York, N. Y.; and John W. Nickerson, director, Management Consultant Division, W.P.B., Washington, D. C.

Education and Training (III)

A Practical Program of Industrial Rehabilitation, by H. A. Vonachen, General Medical Division, Caterpillar Tractor Co., Peoria, Ill.

Motion Picture: Winning Against Odds. Discussion by panel members and question period

Manufactured and Natural Gas—Heat Transfer

Function Fitted Combustion—The Implications of a New Concept of Industrial Gas Utilization, by Harry W. Smith, Jr., manager, technical information department, The Selas Co., Philadelphia, Pa.

Radiant-Tube Heating Applications, by H. H. Armstrong, production manager, Lee Wilson Engineering Co., Cleveland, Ohio

12:30 p.m.

Aviation Luncheon

Winning Battles by Bombing, by Col. Nathaniel F. Silsbee, U.S.A., Air Information Section, News Division, Bureau of Public Relations, War Dept., Washington, D. C.

Student Luncheon

WEDNESDAY (*continued*)

2:00 p.m.

Oil and Gas Power—Railroad—Land Transportation Com. A.I.E.E.

Factors Involved in the Selection of Railroad Motive Power, by Brigadier General C. D. Young, deputy director, Office of Defense Transportation, Washington, D. C.

Power (I)

Report of Joint A.I.E.E.-A.S.M.E. Committee on Tentative Specifications for Speed Governors

Furnace Performance Factors (III)

Papers on furnace geometry of large furnaces and a paper on tube wastage

Production Engineering (II)—Research

Studies in the Wear of Metals in Lathe Beds and Carriages, by W. L. Dolle, president, Lodge & Shipley Machine Tool Co., Cincinnati, Ohio

Surface Fatigue of Plastic Materials,* by Earle Buckingham, department of mechanical engineering, Massachusetts Institute of Technology

Forging of Steel Shells

The Flow-of-Metal Problems in Shell Forging, by M.D. Stone, chairman, Special Research Committee on Forging of Steel Shells, and manager of development, United Engineering & Foundry Co., Pittsburgh, Pa.

Piercing of Steel Shells, by W. Trinks, projects director, Special Research Committee on Forging of Steel Shells, Pittsburgh, Pa.

Drawing of Steel Shells, by George Sachs, department of metallurgy, Case School of Applied Science, Cleveland

Nosing of Steel Shells, by A. Nadai, research laboratories, Westinghouse Electric & Manufacturing Co., Pittsburgh

Aviation-Rubber and Plastics

Current Applications and Future Possibilities of Paper-Base Laminates in Aircraft, by Charles F. Marschner, McDonnell Aircraft Corporation, St. Louis, Mo.

Behavior of Phenolic Resin Bonded Plywood Under Alternating Stresses, by Albert G. H. Dietz, assistant professor, department of building engineering and construction, Massachusetts Institute of Technology, Cambridge, Mass., and Henry Grinsfelder, senior chemist, Resinous Products and Chemical Co., Inc., Philadelphia, Pa.

7:00 p.m.

Annual Dinner

THURSDAY, DECEMBER 2

9:30 a.m.

Furnace Performance Factors (IV)

Papers on heat transfer in furnaces and paper on ash properties

THURSDAY (*continued*)

Oil and Gas Power

Future for Diesel-Engine Fuels, by Arch L. Foster, refinery editor, *The Oil & Gas Journal*, Tulsa, Okla.

The Smith Master-Valve Engine and Its Performance, by Byron E. Short, professor of mechanical engineering, University of Texas, and T. M. Smith, Jr., The Luling Oil & Gas Co., San Antonio, Texas

Applied Mechanics—SESA (I)

Deflections of Uniformly Loaded Circular Plates, by F. C. W. Olson, Glenview, Illinois

Shrink-Fit Stresses and Deformations,* by A. W. Rankin, General Electric Co.

Stress-Coefficients for Rotating Disks of Conical Profile,* by K. E. Bisshopp, design calculator, Fairbanks, Morse & Co., Beloit, Wisconsin

Plastics

Creep Properties of Molded Phenolic Plastics, by David Telfair, T. S. Carswell, and H. K. Nason, Monsanto Chemical Co., plastics division, Springfield, Ohio

Plastic Printing Plates, by William R. McLain, Huntsville, Ala.

Antiscatter Treatments for Glass, by Frank W. Reinhart, Ruth Kronstadt, and Gordon M. Kline, National Bureau of Standards, Washington, D. C.

Textile

Electronic Instrumentation in the Textile Industry, by S. T. Herr, Brown Instrument Co., Providence, R. I.

Instrumentaton and Control in the Textile Industry, by W. B. Heinz, consulting engineer, Bound Brook, N. J., and W. W. Starke, engineer, Forstmann Woolen Co., Passaic, N. J.

Railroad (I)

Possibilities of New Materials to Be Used in Railroad Equipment in the Postwar Period, by C. B. Bryant, engineer of tests, Southern Railway System, Washington, D. C.

Passenger Cars for the Postwar Period, by Edward G. Budd, Edward G. Budd Manufacturing Co., Philadelphia, Pa.

Report of the Committee on Survey, RR-6, by E. G. Young, professor, railway mechanical engineering, University of Illinois, Urbana, Ill.

Report of the Standing Technical Committee—Locomotives, by Lawford H. Fry, director of research, Locomotive Institute, New York, N. Y.

Report of the Standing Technical Committee—Cars, by K. F. Nystrom, mechanical assistant to vice-president, Chicago, Minneapolis St. Paul & Pacific Railroad, Milwaukee, Wis.

12:30 p.m.

Textile Luncheon

(*Program continued on page 846*)

THURSDAY (*continued*)

2:00 p.m.

Railroad Luncheon

Rubber

Inflatable Life-Saving Rafts in the War Effort, by J. G. Kryer, Firestone Tire & Rubber Co., Akron, Ohio

Advances in Rubber and Plastics in 1943

Graphitization of Steel

Papers on graphitization of steel piping

Applied Mechanics—SESA (II)—Power

Bursting Tests of Steam-Turbine Disk Wheels,* by E. L. Robinson, General Electric Co., Schenectady, N. Y.

Measurement of the Dynamic Tensile Strength and the Dynamic Yield Strength on Specimens Fractured at High Impact Velocities, by R. O. Fehr, E. R. Parker, and D. J. DeMicheal, General Electric Co., Schenectady, N. Y.

Relations Between the Notched-Beam Impact Test and the Static Tension Test,* by C. W. MacGregor and J. C. Fisher, Massachusetts Institute of Technology, Cambridge, Mass.

Hydraulics (I)

Hydraulic Torque Converter, by A. Lysholm, chief engineer, Ljungstrom Corporation, Stockholm, Sweden

Mechanical Details and Performance Tests on 30,000-Hp Glenville Unit, the East's Only Large Impulse Turbine, by Arnold Pfau, consulting engineer, hydraulic department, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

Metals Engineering—Manufactured and Natural Gas

The Application of Prepared Atmospheres to the Processing of Metals,* by E. G. de Coriolis, research director, Surface Combustion Corp., Toledo, Ohio

Brass Mill for Government Ordnance, by Paul W. Mueller, Revere Copper and Brass, Inc., Rome, N. Y.

Railroad (II)

Research Possibilities in Railroad Equipment, by W. I. Cantley, mechanical engineer, Association of American Railroads, Chicago, Ill.

Education of Railway Mechanical Engineers for the Postwar Period, by Roy V. Wright, managing editor, *Railway Age*, New York, N. Y.

6:30 p.m.

Joint Dinner: Applied Mechanics—SESA

8:00 p.m.

Aviation—Biomechanics

The Mechanics of Injury Under Forced Conditions, by Hugh DeHaven, department of physiology, Cornell Medical School, New York, N. Y.

THURSDAY (*continued*)

Biomechanics—New Horizons and Safety, by Charles Murray Gratz, M.D., New York, N. Y.

Materials Handling

Discussion on Recent Advances Made by U. S. Navy in Materials Handling Methods, Including the Training of Workers in These Methods, With motion pictures:

Commander O. P. Lattu, U. S. Navy, Washington, D. C.

C. H. Barker, Jr., technical director, containers and materials handling section, Bureau of Supplies and Accounts, U. S. Navy, Washington, D. C. Matthew W. Potts, technical consultant on materials handling, Washington, D. C.

Hydraulics (II)

Maintenance of Hydroelectric Generating Units,* by G. H. Bragg, Pacific Gas & Electric Co., San Francisco, Calif.

Hydraulic Turbine Maintenance, by G. R. Woodman, Southern California Edison Co., Los Angeles, Calif.

Production Engineering (III)

New Method of Testing Bearings for Noise, by Ernest J. Abbott, president, Physicists Research Co., Ann Arbor, Mich.

Application of Electronics to a Machine Tool, General Electric Co.

Heat Transfer Panel Discussion on Experimental Techniques

Discussion on Experimental Determination of Mixed-Mean Fluid Temperatures

Discussion on Special Arrangements for Testing Heat Exchangers

Motion Pictures Illustrating Visual Techniques in the Study of Heat Transfer

Power-Consuming Equipment For Ships

Centrifugal Feedwarer Pumps, by Arvid Peterson, chief engineer, Pump Division, DeLaval Steam Turbine Co., Trenton, N. Y.

Steam Jet Vacuum Pumps, by Robert M. Rohrbaugh, Ingersoll Rand Co., Phillipsburg, N. J.

Air Compressors, by William T. Alderson, Ingersoll Rand Co., New York, N. Y.

Circulating Pumps, by C. R. McBath, chief engineer, centrifugal engineering division, Worthington Pump & Machinery Corporation, Harrison, N. J.

Steering Gears, by Ralph Erling, Lidgerwood Manufacturing Co., Elizabeth, N. J.

Heat Exchangers, by H. E. Carlton, Foster Wheeler Corporation, New York, N. Y.

FRIDAY, DECEMBER 3

9:30 p.m. Council Meeting

Heat Transfer—Drying

Accomodation Coefficients of Metallic Surfaces, by P. R. Trumpler, engineering department, M. W. Kellogg Co., New York, N. Y., and M. L. Wiedmann, assistant professor of mechanical engineering, Stanford University, Calif.

Heat and Vapor Transfer in Dehydration of Prunes, by R. L. Perry, assissant professor, department of agricultural engineering, University of California, Davis, Calif.

Temperature Distribution in Electric Coils, by T. J. Higgins, professor, department of electrical engineering, Illinois Institute of Technology, Chicago, Ill.

Design—Materials Handling

Application and Design of Package Conveyers,* by H. C. Keller, engineering manager, Lamson Corporation, Syracuse, N. Y.

Design Features of Conveying Equipment in the Foundry Industry,* by Fred B. Henry, manager of sales, and George N. Wileman, The Jeffrey Manufacturing Co., Columbus, Ohio

Wood Industries (I)

Radio-Frequency Technology in Wood Applications, by George F. Russell, president, Northwest Syndicate, Inc., Tacoma, Wash., consultant to utronic division, Utah Radio Products Co., Chicago, Ill., and Julius W. Mann, president, Mann Capacitherm Co., vice-president, Northwest Syndicate, Inc., Tacoma Wash.

Glued Laminated Lumber Construction,* by Frank J. Hanrahan, structural engineer, National Lumber Manufacturers Association, Washington, D. C.

Applied Mechanics—Sesa (III)

An Investigation of the Cross-Spring Pivot,* by W. E. Young, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Strain Figures in Plates Under Static and Impact Loads as Obtained by the Brittle-Lacquer Method, by M. Hetényi, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Power (II)

Theoretical Regenerative-Steam-Cycle Heat Rates,* by A. M. Selvey, engineer engineering division, The Detroit Edison Co., and P. H. Knowlton, engineer, turbine engineering department, General Elec. Co., Detroit, Mich.

Fluid Flow Through Two Orifices in Series,* by M. C. Stuart, professor of mechanical engineering, Lehigh University, Bethlehem, Pa., and D. Robert Yarnall, Yarnall Waring Co., Philadelphia, Pa.

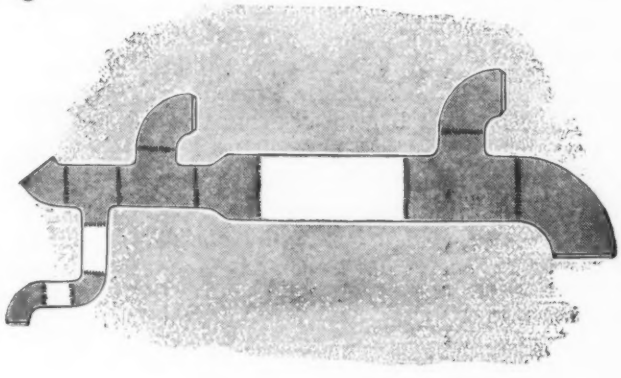
(*Program continued on page 848*)

NO. 10 OF A SERIES

HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY

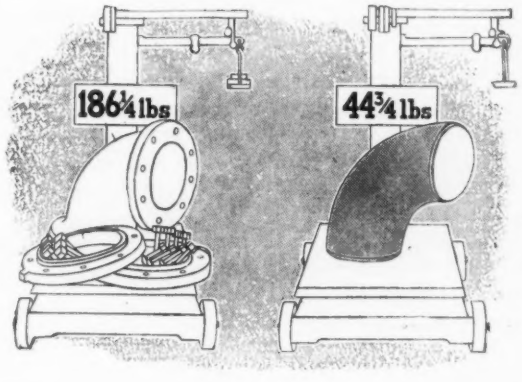
THE FIRST SEAMLESS WELDING FITTINGS 1ST AND STILL THE BEST

Improve industrial piping 4 ways with Tube-Turn welding fittings!



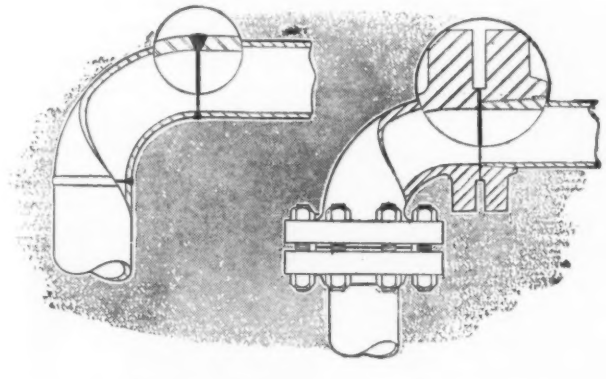
1. Easily preassembled—speed installation

Save from 50% to 75% time by pre-assembling difficult piping sections like this in the shop. Tube-Turn fittings are ready to use. They simplify lining-up, require only easy, circumferential butt welds. This insures faster, better and safer welding by either veteran or novice welders—a real war production help.



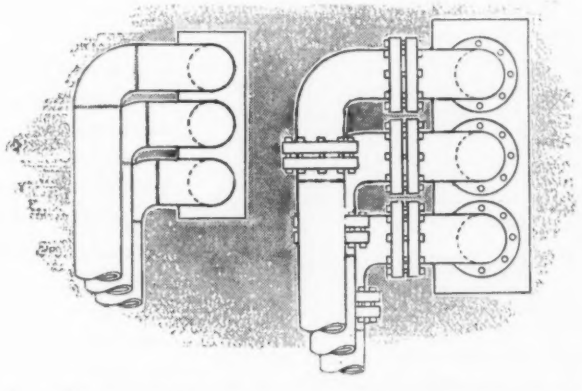
2. Reduce weight—conserve materials

Look at the weight saved by using an 8" Tube-Turn elbow instead of a heavy 8" cast iron flanged ell with companion flanges, studs and nuts. Multiply this saving by the many fittings in any piping system and it's easy to see how Tube-Turn fittings save tons of weight, metal and critical materials.



3. Avoid "down time"—reduce maintenance

Note how the welded connection virtually forms a continuous tube without joints—insures permanently leakproof, trouble-free connections that last as long as the pipe itself! Such maintenance headaches as leaks, gasket changes, bolt tightening, caulking, threading, and difficult insulatings are totally eliminated.



4. Streamline systems—save space

Contrast the space saved in these compound turns by using Tube-Turn elbows instead of flanges. Tube-Turn fittings require less space, permit streamlined, compact layouts and neater, more efficient piping. Elbows can be cut to any odd angle. Saving space is important in most industries, is vital in shipbuilding!

TUBE TURNS (INC.) Louisville, Ky. *Branch offices:* New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Dayton, Washington, D. C., Houston, San Francisco, Seattle. *Distributors in principal cities.*

TUBE-TURN *Welding Fittings and Flanges*

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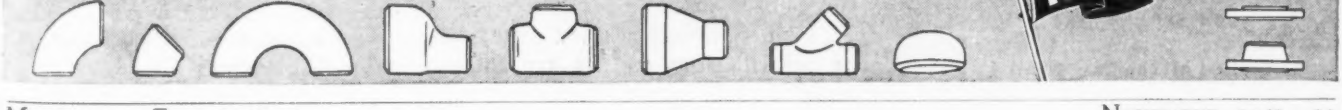


FRIDAY (*continued*)

12:30 p.m.

Wood Industries Luncheon

Talk by Arthur Loerke, chief engineer, duramold division, Fairchild Engine & Airplane Corporation, New York, N. Y.

Wood Industries (II)

2:00 p.m.

Technical Veneer and Plywood in England, by George R. Thompson, industrial specialist, Plywood and Veneer Distribution Section, Lumber and Lumber Products Division, War Production Board, Washington, D. C.

Master Shop Schedules, A Flexible Production Control Plan for War and Postwar Aircraft Manufacture, by Henry S. Jones, assistant works manager, Phil I. Harr, production manager, and Palmer B. Hager, supervisor, production control, Fairchild Aircraft Corporation, Hagerstown, Md.

Power (III)

Investigation of Blade Characteristics,* by John Weske, Case School of Applied Science, Cleveland, Ohio

Notch Toughness Tests of Carbon-Molybdenum Piping Material,* by W. F. Kinney, I. A. Rohrig, research department, H. S. Walker, director of research, The Detroit Edison Co., Detroit, Mich.

Design

The Theory and Design of Electronic Control Apparatus,* by W. D. Cockrell, industrial engineering division, General Electric Co., Schenectady, N. Y.

Application of Electronic Control,* by E. H. Vedder, manager, electronic control section, application department, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Aviation—Heat Transfer

Temperature Control, by J. R. Campbell, design engineer, General Electric Co.

Temperature Measurement in High Velocity Air Streams, by H. C. Hottel, professor, department of chemical engineering, Massachusetts Institute of Technology, and A. Kalatinsky, Pratt & Whitney Aircraft, East Hartford, Conn.

Pressure Losses in Elbows and Duct Branches, by A. Vazsonyi, Harvard Graduate School of Engineering

Applied Mechanics—SESA (IV)

Professional Division and Technical Committees Conference

SATURDAY, DECEMBER 4

9:30 a.m.

Applied Mechanics—SESA (V)

A.S.M.E. Medals and Honorary Memberships to Be Conferred at the Coming 1943 Annual Meeting

WITH impressive and appropriate ceremonies, awards and honors for the year 1943 will be conferred at the Annual Meeting of The American Society of Mechanical Engineers to be held at the Pennsylvania Hotel, New York, N. Y., Nov. 29–Dec. 3, 1943. Recipients of awards and honors are as follows:

Honorary Membership in The American Society of Mechanical Engineers to Francis Blossom, partner in the firm of Sanderson and Porter, New York, N. Y., "because of his many years of engineering and war usefulness; his courage, sound judgment, and high standards; engineers nationwide, hold him in the highest esteem."

Honorary Membership in The American Society of Mechanical Engineers to Ralph Budd, president of the Burlington Lines, Chicago, Ill.—"Forty years a railroader; a pioneer in the development of Diesel-powered lightweight trains; civil engineer and executive; builder of railroad structures and railroad organizations; President of the Burlington Lines."

Honorary Membership in The American Society of Mechanical Engineers to Edward Needles Trump, senior member in the firm of E. N. & C. C. Trump, Syracuse, N. Y., "for distinguished service in the design of furnaces and machinery in the fields of mining, chemical, and mechanical engineering."

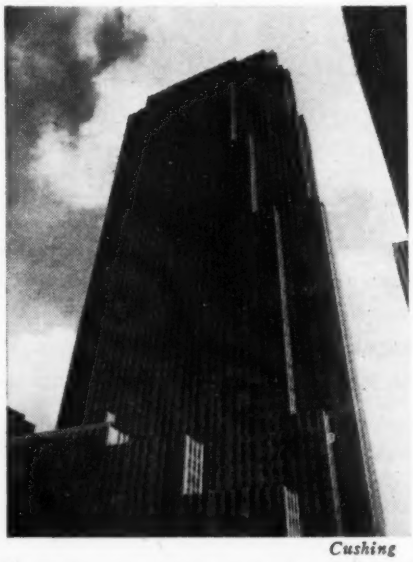
Honorary Membership in The American Society of Mechanical Engineers to Roydon Vincent Wright, vice-president and secretary, Simmons-Boardman Publishing Corporation, New York, N. Y.—"International authority in railroad engineering, oft honored as author, editor, publisher, teacher, statesman, an amiable competent crusader for social and civic responsibilities of the engineer."

A.S.M.E. Medal to Lewis Ketcham Sillcox, first vice-president, New York Air Brake Company, Watertown, N. Y.—"Eminent engineer executive, distinguished lecturer, beloved gentleman and a lover of wisdom, for his pre-eminent and permanent contributions to the art and science of engineering, of transportation, of education, and the fine art of living. And for his ingratiating, inspiring influence upon the lives of men."

The Holley Medal to Vannevar Bush, president, Carnegie Institute of Washington, Washington, D. C.—"Engineering educator, inventor, and leader in scientific research, for leadership and inventions in easing applied mathematics from computational barriers; and particularly for the differential analyzer that has enlarged differential equation analysis, thereby providing improved analyses in such fields as atomic physics, cosmic rays, ballistics, and automatic control and improved opportunities for understanding various electrical, mechanical, and other physical systems associated with engineering."

Worcester Reed Warner Medal to Igor Ivan Sikorsky, Vought-Sikorsky Aircraft, Stratford, Conn., "for his stimulation of the engineer in the attainment and practice of those priceless attributes, imagination and creative ability, as notably exemplified in his book 'The Story of the Winged—S', his Steinmetz Memorial Lecture, 'Science and the Future of Aviation,' and his timely address at the 1942

(*A.S.M.E. News continued on page 850*)



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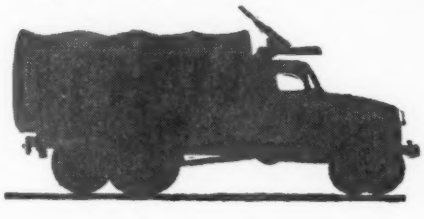

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THERMEX puts one of the miracles of tomorrow's electronics at your disposal today! Miracles? Yes! Thermex high frequency equipment performs in minutes, or even seconds, heating operations that formerly took hours. Thermex heats better, faster, more uniformly—regardless of thickness of material.

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Annual Meeting of The American Society of Mechanical Engineers on the subject of 'Creative Engineering, Inventiveness, and Intuition.' His writings and addresses, supported by his significant contributions to the science of aviation and to the growing aviation industry, especially the development of the large flying ship and the helicopter, have given encouragement and great inspiration particularly to the young engineer engaged in scientific research and engineering development activities."

Junior Award to Troels Warming, mechanical engineer, Nordberg Manufacturing Company, Milwaukee, Wis., for his paper "Power Pulsations Between Synchronous Generators."

Charles T. Main Award to Mitchell Christopher Kazen of the University of Detroit, tool designer, Cook Engineering Co., Detroit, Mich., for his paper "Government as Affected by Engineering."

Undergraduate Student Award to William Langdon Hutton of Princeton University, Ensign, U.S.N.R., for his paper "The Aerodynamic Development of the Star Sail."

Preprints of 1943 Annual Meeting Papers

AS USUAL, a considerable number of papers to be presented at the 1943 A.S.M.E. Annual Meeting to be held at the Pennsylvania Hotel, New York 18, N. Y., Nov. 29 to Dec. 3, 1943, will be available in preprint form in advance of the Meeting.

The program of the Meeting which appears on pages 843–848 of this issue indicates the papers to be ready (so far as is known at press date) for distribution in advance of the Meeting. A few additional papers, received too late for preprinting in advance of this issue date, will be available at the sessions. Requests for papers should be addressed to the Secretary, The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y. In so far as possible, orders received in time will be filled.

A charge will be made for preprints of A.S.M.E. papers. The following schedule of prices will be in effect:

Size of papers, pages	Price per copy — At registration desk	By mail
12 or fewer	$0.10	$0.15
16	0.15	0.20
20	0.20	0.25
24 or more	0.25	0.30

Remittance should accompany orders which should be sent to A.S.M.E. Headquarters, 29 West 39th St., New York 18, N. Y.

Since it is not possible to state at this writing the number of pages in these papers, we suggest that twenty cents be forwarded for each preprint ordered. Any over-remittance will be refunded in stamps.

Biomechanics Subject of New York A.A.A.S. Meeting, Nov. 3

A SYMPOSIUM on Biomechanics with special reference to high-altitude flying will be held on Wednesday, Nov. 3, 1943, in the Engineering Societies Auditorium, 29 West 39th Street, New York, N. Y., at 7:30 p.m. under the joint sponsorship of the Engineering Section of A.A.A.S. and the Biomechanics Committee of the A.S.M.E.

The various researches connected with biomechanics are of interest to scientists in the engineering and medical fields as well as to those in biology, physiology, psychology, and physics.

The papers to be presented are:

1 "The Application of Engineering Principles to Clinical and Aviation Medicine," by Alvan L. Barach., M.D., associate professor of clinical medicine, college of Physicians and Surgeons, which will deal with the development and uses of oxygen equipment.

2 "Simulation of High-Altitude Flying in the Laboratory," by E. Lodwig, chief engineer, Mobile Refrigeration, Inc., New York, N. Y.

3 "Some of the Problems of High-Altitude Flying," by Dr. Irving Fink, flight surgeon for the airlines having headquarters at the Newark Airport, and also for Army Air Corps.

Some of the papers are accompanied by slides and it is hoped that lively discussions will follow the presentation of the individual papers.

The medical and technological problems involved in flying at high altitudes, such as 30-000 ft, for example, where the temperature is —48 F and the air pressure little less than a third that at sea level, should be of interest to engineers as well as to medical men.

The chairman of the meeting will be Dean Thorndike Saville, of the College of Engineering, New York University, who is chairman of Section M (Engineering), A.A.A.S.

Registration Fee for Non-Members at the 1943 Annual Meeting

There will be a registration fee of $2 for nonmembers attending the 1943 Annual Meeting. For nonmembers wishing to attend just one session (except evening sessions or meal meetings) the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests (male) may avoid this fee by writing to the Secretary of the Society before November 22 asking for a guest-attendance card for the Annual Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member*.

A.P.C. to Exhibit 45,000 Patents at A.S.M.E. Annual Meeting

THE Alien Property Custodian of the United States Government will exhibit some 45,000 copies of vested United States patents and patent applications at the Annual Meeting of The American Society of Mechanical Engineers at the Pennsylvania Hotel, New York, N. Y., Nov. 29–Dec. 3, 1943.

These patents and patent applications in the mechanical, electrical, and chemical fields were formerly enemy-owned or enemy-controlled but are now controlled by the Alien Property Custodian. All are available for use on liberal licensing terms, unless already subject to a prewar exclusive license granted by the original owner to an American firm. Many of the finest research products of the enemy are represented by these inventions.

This exhibit will be in furtherance of the Custodian's pledges:

. . . . first, that the patents directly controlled by this agency of Government will be available readily and immediately to serve all American industry, and that active use of the store of technical knowledge which these patents represent will be fostered; second, we pledge that we shall encourage further research on these inventions for the lasting benefit of American industry, American labor, and the consuming public; and third, we shall take all steps within our power to make certain that vested enemy patents are made available forever to American industry.

Leo T. Crowley, Alien Property Custodian, invites critical examination of these patents and patent applications and hopes that American industry will assume its reponsibility in realizing the full potentialities of the information covered by the vested patents and applications by employing these inventions in the war effort wherever possible and developing them for the postwar period.

Representatives of the Custodian's Office will be present to answer questions concerning these inventions or the licensing policy of the Custodian.